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1970-1971

The Pennsylvania State University Bulletin

Graduate Degree Programs

1970-1971

THE PENNSYLVANIA STATE UNIVERSITY

GRADUATE DEGREE PROGRAMS

GENERAL CATALOG ISSUE

FEBRUARY 1970

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THE PENNSYLVANIA STATE UNIVERSITY BULLETIN

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GRADUATE CALENDAR *

WINTER TERM 1970

NOVEMBER 1969

3 Monday—Last Date for a Prospective Graduate Student to Apply for Admission to the Winter Term 1970

DECEMBER

3 Wednesday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Winter Term 1970

JANUARY 1970

3 Saturday—Winter Term Registration
2-3 Friday to Saturday Noon—Pre-examinations in German for Advanced Degree Candidates
5 Monday—Winter Term Classes Begin 8 a.m.
7 Wednesday—Last Date for Registering with French and Spanish Departments for Written Language Examinations
9 Friday—Last Date for Registering with Foreign Language Departments (Other than French and Spanish) for Written Language Examinations
20 Tuesday—Graduate Faculty Meeting
21 Wednesday—Last Date for a March Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office
24 Saturday—Last Date for a March Graduate to Deliver Doctoral Thesis to Committee
27 Tuesday—Last Date for Written Foreign Language Examinations (Other than French and Spanish) for Advanced Degree Candidates
31 Saturday—Written French and Spanish Language Examinations for Advanced Degree
31 Saturday—Last Date for Final Oral Doctoral Examination for March Graduates
31 Saturday—Last Date for a March Graduate to Deliver Master's Thesis or Paper to Adviser

FEBRUARY

16 Monday—Last Date for a March Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Completion of Required Papers
16 Monday—Last Date for a March Graduate to Order Cap, Gown, and Hood Locally

MARCH

7 Saturday a.m.—Last Date for Submitting a Petition to Graduate in Absentia in March
14 Saturday—Winter Term Classes End 12:25 p.m.
16-19 Monday to Thursday—Final Examinations
22 Sunday—Commencement

SPRING TERM 1970

JANUARY 1970

26 Monday—Last Date for a Prospective Graduate Student to Apply for Admission to the Spring Term 1970

* This calendar was approved by the Board of Trustees and is subject to change without notice. In preparing the calendar for an academic year, the University makes every effort to avoid conflicts with religious holidays. However, such conflicts are sometimes unavoidable. When they occur, efforts are made to make special arrangements for the students affected.

FEBRUARY

25 Wednesday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Spring Term 1970

MARCH

27-28 Friday to Saturday noon—Pre-examinations in German for Advanced Degree Candidates

28 Saturday—Spring Term Registration

30 Monday—Spring Term Classes Begin 8 a.m.

APRIL

3 Friday—Last Date for Registering with Foreign Language Departments (Other than French and Spanish) for Written Language Examinations

8 Wednesday—Last Date for Registering with French and Spanish Departments for Written Language Examinations

16 Thursday—Last Date for a June Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office

18 Saturday—Last Date for a June Graduate to Deliver Doctoral Thesis to Committee

21 Tuesday—Last Date for Written Foreign Language Examinations (Other than French and Spanish) for Advanced Degree Candidates

21 Tuesday—Graduate Faculty Meeting

25 Saturday—Last Date for Final Oral Doctoral Examination for June Graduates

25 Saturday—Last Date for a June Graduate to Deliver Master's Thesis or Paper to Adviser

MAY

2 Saturday—Written French and Spanish Language Examinations for Advanced Degree Candidates

11 Monday—Last Date for a June Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Completion of Required Papers

11 Monday—Last Date for a June Graduate to Order Cap, Gown, and Hood Locally

30 Saturday a.m.—Last Date for Submitting a Petition to Graduate in Absentia in June

JUNE

6 Saturday—Spring Term Classes End 12:25 p.m.

8-11 Monday to Thursday—Final Examinations

13 Saturday—Commencement

SUMMER TERM 1970

APRIL 1970

20 Monday—Last Date for a Prospective Graduate Student to Apply for Admission to the Summer Term 1970

MAY

19 Tuesday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Summer Term 1970

JUNE

18-19 Thursday and Friday—Pre-examinations in German for Advanced Degree Candidates

18-19 Thursday and Friday—Summer Term Registration

22 Monday—Summer Term Classes Begin 8 a.m.

24 Wednesday—Last Date for Registering with French and Spanish Departments for Written Language Examinations

26 Friday—Last Date for Registering with Foreign Language Departments (Other than French and Spanish) for Written Language Examinations

JULY

4 Saturday—Independence Day Holiday
9 Thursday—Last Date for a September Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office
11 Saturday—Last Date for a September Graduate to Deliver Doctoral Thesis to Committee
14 Tuesday—Last Date for Written Foreign Language Examinations (Other than French and Spanish) for Advanced Degree Candidates
18 Saturday—Last Date for Final Oral Doctoral Examination for September Graduates
18 Saturday—Last Date for a September Graduate to Deliver Master's Thesis or Paper to Adviser
18 Saturday—Written French and Spanish Language Examinations for Advanced Degree Candidates
21 Tuesday—Graduate Faculty Meeting

AUGUST

3 Monday—Last Date for a September Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Completion of Required Papers
3 Monday—Last Date for a September Graduate to Order Cap, Gown, and Hood Locally
22 Saturday a.m.—Last Date for Submitting a Petition to Graduate in Absentia in September
31 Monday—Summer Term Classes End 9:55 p.m.

SEPTEMBER

1-2 Tuesday and Wednesday—Final Examinations
5 Saturday—Commencement

FALL TERM 1970

JULY 1970

24 Friday—Last Date for a Prospective Graduate Student to Apply for Admission to the Fall Term 1970

AUGUST

24 Monday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Fall Term 1970

SEPTEMBER

23-25 Wednesday to Friday—Pre-examinations in German for Advanced Degree Candidates
23-25 Wednesday to Friday—Fall Term Registration
28 Monday—Fall Term Classes Begin 8 a.m.

OCTOBER

2 Friday—Last Date for Registering with Foreign Language Departments (Other than French and Spanish)* for Written Language Examinations
15 Thursday—Last Date for a December Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office
17 Saturday—Last Date for a December Graduate to Deliver Doctoral Thesis to Committee
20 Tuesday—Last Date for Written Foreign Language Examinations (Other than French and Spanish)* for Advanced Degree Candidates
20 Tuesday—Graduate Faculty Meeting

* Information pertaining to foreign language examination schedules in French and Spanish may be obtained from the respective Departments.

24 Saturday—Last Date for Final Oral Doctoral Examination for December Graduates

24 Saturday—Last Date for a December Graduate to Deliver Master's Thesis or Paper to Adviser

NOVEMBER

9 Monday—Last Date for a December Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Completion of Required Papers

9 Monday—Last Date for a December Graduate to Order Cap, Gown, and Hood Locally

26 Thursday—Thanksgiving Day Holiday

28 Saturday a.m.—Last Date for Submitting a Petition to Graduate in Absentia in December

DECEMBER

7 Monday—Fall Term Classes End 9:55 p.m.

8-11 Tuesday to Friday—Final Examinations

13 Sunday—Commencement

WINTER TERM 1971

NOVEMBER 1970

9 Monday—Last Date for a Prospective Graduate Student to Apply for Admission to the Winter Term 1971

DECEMBER

9 Wednesday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Winter Term 1971

JANUARY 1971

8-9 Friday and Saturday—Pre-examinations in German for Advanced Degree Candidates

8 Friday—Winter Term Registration

11 Monday—Winter Term Classes Begin 8 a.m.

15 Friday—Last Date for Registering with Foreign Language Departments (Other than French and Spanish)* for Written Language Examinations

19 Tuesday—Graduate Faculty Meeting

28 Thursday—Last Date for a March Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office

30 Saturday—Last Date for a March Graduate to Deliver Doctoral Thesis to Committee

FEBRUARY

2 Tuesday—Last Date for Written Foreign Language Examinations (Other than French and Spanish)* for Advanced Degree Candidates

6 Saturday—Last Date for Final Oral Doctoral Examination for March Graduates

6 Saturday—Last Date for a March Graduate to Deliver Master's Thesis or Paper to Adviser

20 Monday—Last Date for a March Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Completion of Required Papers

20 Monday—Last Date for a March Graduate to Order Cap, Gown, and Hood Locally

* Information pertaining to foreign language examination schedules in French and Spanish may be obtained from the respective Departments.

MARCH

13 Saturday a.m.—Last Date for Submitting a Petition to Graduate in Absentia in March
20 Saturday—Winter Term Classes End 9:55 p.m.
22-25 Monday to Thursday—Final Examinations
28 Sunday—Commencement

SPRING TERM 1971

FEBRUARY 1971

1 Monday—Last Date for a Prospective Graduate Student to Apply for Admission to the Spring Term 1971

MARCH

3 Wednesday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Spring Term 1971

APRIL

2-3 Friday and Saturday—Pre-examinations in German for Advanced Degree Candidates
2 Friday—Spring Term Registration
5 Monday—Spring Term Classes Begin 8 a.m.
9 Friday—Last Date for Registering with Foreign Language Departments (Other than French and Spanish)* for Written Language Examinations
20 Tuesday—Graduate Faculty Meeting
22 Thursday—Last Date for a June Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office
24 Saturday—Last Date for a June Graduate to Deliver Doctoral Thesis to Committee
27 Tuesday—Last Date for Written Foreign Language Examinations (Other than French and Spanish)* for Advanced Degree Candidates

MAY

1 Saturday—Last Date for Final Oral Doctoral Examination for June Graduates
1 Saturday—Last Date for a June Graduate to Deliver Master's Thesis or Paper to Adviser
17 Monday—Last Date for a June Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Completion of Required Papers
17 Monday—Last Date for a June Graduate to Order Cap, Gown, and Hood Locally

JUNE

5 Saturday a.m.—Last Date for Submitting a Petition to Graduate in Absentia in June
12 Saturday—Spring Term Classes End 12:25 p.m.
14-17 Monday to Thursday—Final Examinations
19 Saturday—Commencement

* Information pertaining to foreign language examination schedules in French and Spanish may be obtained from the respective Departments.

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GENERAL INFORMATION

GRADUATE WORK at The Pennsylvania State University began in 1862 with two graduate students in residence. Two years later a "course for Graduates," which led to the degree of Master of Scientific Agriculture, was formally established, but for a number of years growth was slow and graduate instruction relatively unorganized. Eventually a committee of the University Senate was given the responsibility of guiding graduate study. Standards were established, and regulations were set up to govern the conferring of master's degrees and certain technical degrees. In 1922 the Graduate School was organized, and in 1924 the Board of Trustees authorized the granting of the degree of Doctor of Philosophy.

Today graduate study is offered in 115 major fields, with thirteen advanced academic and professional degrees being conferred. During the academic year 1968-69, 4,000 to 4,500 graduate students were enrolled each term, and 1,481 advanced degrees were conferred, of which 344 were doctorates. The faculty of the Graduate School, numbering about 1,150, controls all academic matters pertaining to the School, subject to review by the University Senate.

GRADUATE CENTERS—University Graduate Centers have been established in the Erie, Philadelphia, and Harrisburg areas. They operate under the immediate direction of a resident representative of the Graduate School and have full-time resident faculty members as well as part-time staff. Programs to be offered in a Center will depend upon its location, the degree of interest, and the availability of qualified students in the immediate area.

Interested students may write directly to the Dean at the Center for information on programs and courses. Addresses are given on page 2.

Behrend Graduate Center—The Behrend Graduate Center at Erie opened with the winter term, January 1969, and provides convenient opportunity for graduate education to persons residing in northwestern Pennsylvania. It has been established to offer individual courses and a program leading to the degree of Master of Engineering with a major in engineering science.

King of Prussia Graduate Center—The King of Prussia Graduate Center near Philadelphia opened in 1963. Its program leads to the degree of Master of Engineering with a major in engineering science.

The Capitol Campus—The Capitol Campus, located near Middletown and named for its proximity to the State Capitol, was opened in 1966. Graduate programs leading to the degrees of Master of Administration, Master of Education with a major in elementary education, Master of Engineering with a major in engineering science, and Master of Regional Planning are currently offered; others are in the planning stage. Further details about the graduate programs and courses are given in The Capitol Campus catalog, obtainable from the Office of Admissions, The Capitol Campus, Middletown, Pa. 17057.

The Milton S. Hershey Medical Center—The University's Medical Center was established in 1963, and the first class of medical students entered in the fall of 1967. The Center is located in Hershey, Pennsylvania, twelve miles from Harrisburg, and all teaching and research facilities at the Campus are new. The Medical Sciences Building and the Animal Research Farm are completed; a 350-bed Teaching Hospital, built as a continuous unit with the Medical Sciences Building, will be completed in the fall of 1970.

In conjunction with The Pennsylvania State University's Graduate School, the College of Medicine offers programs leading to the M.S. degree with a major in laboratory animal medicine, and to the M.S. and Ph.D. degrees with majors in anatomy, biological chemistry, pharmacology, and physiology. Postdoctoral fellows are in resi-

dence in all the basic sciences. Additional information about the graduate programs and course descriptions at the Medical Center can be found in The Milton S. Hershey Medical Center catalog. Copies of the catalog may be obtained by contacting the Dean of the College, The Milton S. Hershey Medical Center, 500 Hershey Drive, Hershey, Pa. 17033.

COOPERATIVE ARRANGEMENTS WITH OTHER INSTITUTIONS—A working arrangement has been established with Jefferson Medical College of Philadelphia whereby a candidate for an advanced degree at Jefferson may do part of his graduate work at Penn State by scheduling relevant courses and research at University Park. Similarly, a graduate student with an appropriate major at Penn State may earn credits at Jefferson which, upon advance approval by his major department, will be accepted in partial fulfillment of degree requirements at Penn State.

PROCEDURES AND REGULATIONS

A student is expected to assume full responsibility for knowing the regulations and pertinent procedures of the Graduate School as set forth in this publication, the *Manual for Graduate Students,* and the *Thesis Information Bulletin,* and for meeting the standards and requirements expressed by these regulations. The *Manual,* which is available to a student after he has been admitted, sets forth in more detail the procedures governing registration, changes in program, and graduation, and gives other information about the Graduate School which is useful to graduate students. Every student should secure a copy from the Dean's office soon after admission.

ADMISSION

An applicant for admission to the Graduate School should understand that graduate work is not a simple extension of an undergraduate program. It operates at a higher level, demands scholarship of a higher order, and emphasizes research, creativity, and professional competence with a minimum of formal requirements and a maximum of student initiative and responsibility.

Applicants must recognize that staff, facilities, and other resources are limited so that not all qualified persons can be admitted. The number accepted will vary by department and from term to term. In some fields all vacancies will have been filled long before the deadline for submitting applications so that even outstanding students cannot be accepted. The objective of the Graduate School is to admit a graduate student body of high qualifications up to the limit of the University's resources to provide graduate programs of outstanding quality. In general, a student may begin his graduate work in fall, winter, spring, or summer.

For admission to the Graduate School an applicant must have received a baccalaureate degree from an accredited institution, earned under residence and credit conditions substantially equivalent to those required by The Pennsylvania State University. He must ordinarily have completed in a satisfactory manner a certain minimum of course work in designated areas, the specific courses and amount of work depending upon the field of advanced work which the student proposes to enter.

Admission is granted jointly by the Dean of the Graduate School and the department in which the student plans to follow his studies. The establishment of standards by which applicants are admitted is a departmental responsibility. Though the Graduate School has no fixed minimum grade point requirement for admission, an applicant is generally expected to maintain during his junior and senior years quality in his work equivalent to a grade point average of at least 2.50 on The Pennsylvania State University grading scale of A (4) to D (1). Individual departments may estab-

lish higher grade point averages and other criteria by which they will judge candidates for admission. Departments may also, in exceptional cases, approve admission by reason of special backgrounds, abilities, and interests. Departmental requirements are given in the descriptive statements appearing under the major fields listed in the latter part of this publication.

The above requirements apply particularly to the student who recently completed an undergraduate program and is about to begin graduate study. An applicant who has obtained a graduate degree at a recognized graduate school will be evaluated largely on the basis of the graduate record.

Forms to be used in applying for admission can be obtained from the Graduate School office. All academic records, and explanation of the grading system used, should be submitted, in duplicate, to the Graduate School admissions office. These should be sent directly from all institutions to the Graduate School at least two months prior to the opening of the term in which he plans to begin his graduate program. If the applicant has attended more than one institution, two official transcripts of the work covered at each institution are required. This applies to the complete academic record, both undergraduate and graduate.

A student with a slight deficiency in undergraduate preparation may be admitted and allowed to take a limited number of undergraduate courses to make up the deficiency while proceeding with his graduate program. Courses taken for this purpose do not, of course, apply toward the requirements of the advanced degree.

Admission may be granted to applicants whose credentials are not complete at the time of application because the baccalaureate degree has not yet been conferred, grades for the current term are not yet available, etc. Such admission is subject to cancellation if the complete credentials, on arrival, do not meet the requirements for admission. In the interim, certification of any earned credits will be withheld. If admission should, for any reason, be canceled, the student is thereby automatically dropped from the Graduate School.

A student who plans to take courses for transfer to another institution or to follow a program of study not leading to an advanced degree at this institution should apply for admission as a nondegree student. The adviser for such a student is appointed by the department head most closely associated with the student's field of interests. The number of nondegree students which can be admitted is limited because preference is given to students in degree programs.

A student who has been admitted to a field in which the doctorate is offered may begin working toward that degree, but he has no official status as a doctoral student and no assurance that he will be accepted as a doctoral candidate until he has passed a candidacy examination administered by his major department or committee.

ADVISERS—To assist the student in planning his program, the head of his major department will designate a member of the faculty to serve as adviser. It is the student's responsibility to secure the name of his adviser from the department head and to seek a conference before registration.

ENGLISH PROFICIENCY OF FOREIGN STUDENTS—Entering graduate students from countries other than the United States are required to demonstrate high level competence in the use of the English language, including reading, writing, speaking, and listening. Upon arrival at the University, such students are requested to report to the Office of International Student Affairs, where an appointment for the English language proficiency interview will be made. Students with an obviously good command of English will be exempted from formal testing; others will be scheduled for a series of proficiency tests. Remedial work will be prescribed as indicated by the tests.

Before a foreign student can be accepted for enrollment at The Milton S. Hershey Medical Center a high level competence in the use of the English language must be demonstrated by successful performance on the TOEFL (Test of English as a Foreign Language). Information on the time and place that this test is given in his

geographical area can be obtained by writing to the Educational Testing Service, Box 592, Princeton, New Jersey 08540.

GUESTS OF THE UNIVERSITY—The President, on recommendation of the Dean of the Graduate School, will welcome as guests holders of earned doctor's degrees who may be visiting the University Park Campus for purposes of noncredit study. Guest privileges apply to persons holding the degree from The Pennsylvania State University or other accredited colleges and universities. Guests may attend seminars and courses and, if space and facilities are available, carry on research. There will be no charge except for laboratory expenses. Arrangements should be made in advance with the Dean of the Graduate School.

UNDERGRADUATE STUDENTS—A senior student of The Pennsylvania State University lacking not more than 4 credits for graduation may be admitted to the Graduate School. This limit may be increased to 8 credits in the case of a student with an average of at least B (a grade point average of 3.00). Any senior with a 3.50 grade point average may be admitted to 500-level courses with the consent of the instructor; other undergraduate students with a B average or better may be admitted to such courses with the consent of the instructor and the Dean of the Graduate School.

In certain cases undergraduate students may subsequently apply credits they have earned in 400 and 500 series courses toward an advanced degree at Penn State. Upon admission to the Graduate School such credits as are relevant to the graduate field of study and were not used to satisfy undergraduate requirements will be entered on the student's graduate transcript. These may then be applied toward an advanced degree provided they are acceptable to the major and minor departments. The time limitation on the completion of a master's degree program applies to these as well as to other credits.

UNSATISFACTORY SCHOLARSHIP

A graduate student who fails to maintain satisfactory scholarship or to make acceptable progress in his degree program will be dropped from the University. Action may be initiated by the department or committee in charge of the graduate major or by the chairman of the student's doctoral committee.

CLASSIFICATION

At the time of admission to the University a student is classified as a graduate, adjunct, or undergraduate student depending upon his objectives and qualifications. A graduate student may be admitted either as a degree student or a nondegree student depending upon his objectives. After admission to one of these categories, any change to the other must be arranged through the Graduate School office.

DEGREE STUDENTS—Persons who plan to become candidates for advanced degrees at The Pennsylvania State University and who have been formally admitted for advanced study in a particular field are designated as degree students. The program of study is developed under the guidance of an adviser appointed by the head of the student's major department.

A degree student who has passed a candidacy evaluation is classified as a doctoral candidate.

NONDEGREE STUDENTS—An applicant who meets all requirements for admission to the Graduate School, but who does not wish to work for an advanced degree at

this institution, may arrange for a program of work as a nondegree student. This classification includes any who plan to transfer credits to another institution and those who plan special programs of study not leading to an advanced degree. The number of nondegree students who can be admitted is limited, and it is increasingly difficult to provide for them because of the limitation of total enrollment. Preference is given to students in degree programs.

If a nondegree student wishes to consult an adviser, one will be appointed upon request to the department head most closely associated with the student's field of interest. The student's status and standing will be reviewed by the Dean of the Graduate School at each registration. He may remain a nondegree student longer than one term only with the permission of the Dean, and for definite and good reasons.

ADJUNCT STUDENTS—An adjunct student is not a graduate student, inasmuch as he has not been admitted to the Graduate School, and may not register for graduate courses or research (500 and 600 series) without permission of the Dean of the Graduate School. An adjunct student may register for 400-level courses provided he has attained at least junior standing in college.

Credits earned as an adjunct student may not ordinarily be applied subsequently toward an advanced degree.

REGISTRATION

The responsibility for being properly registered rests with the student. At least until his program is near completion, he is expected to register for each term in which he proposes to do either course work or research toward his thesis, whether it be on or off campus. In the case of research, the number of credits shall be determined by the amount of time required for the investigation, one credit representing the equivalent of one week of full-time work. In the later stages of his program the situation will determine the requirements for the student's registration.

CONTINUITY OF REGISTRATION—A student who registers at University Park without interruption for each of the three terms in the September to June interval, for all four terms each year, or for each summer term is considered to have maintained a normal continuity of registration.

Anyone who has interrupted such a normal sequence and now plans to register for work at the University Park Campus is required to apply to the Dean of the Graduate School at least one month before the time of registration for permission to resume study.

The policy may be summarized for any specific term as follows:

Summer Term—Application required unless the student was registered at University Park for the preceding spring term or the preceding summer term.

Fall Term—Application required unless the student was registered at University Park for the preceding summer term or the preceding spring term.

Winter Term—Application required unless the student was registered at University Park for the preceding fall term.

Spring Term—Application required unless the student was registered at University Park for the preceding winter term.

PROCEDURE—For each registration the student, in consultation with his adviser, prepares a schedule of courses and research designed to fit his individual needs. The credit load will be reviewed by the Dean of the Graduate School at the time of registration. The registration process is completed in the manner specified for all students at the University.

Under certain conditions credit may be earned by work done away from the campus. A student contemplating such work should inquire of the Dean of the Graduate School about the procedures and conditions. The student must assume responsibility for the registration process, but the operation can be handled by mail. Registration must be completed before the close of central registration at University Park.

A student must register for courses audited as well as for those taken for credit.

REGISTRATION NEAR THE COMPLETION OF A PROGRAM—A candidate for the Ph.D. degree who is following the new regulations, which went into effect in the fall term 1967, is required to register continuously (at least three terms per calendar year) from the time he has both passed the comprehensive examination and met the three-term full-time academic requirement until his thesis is accepted by his doctoral committee, regardless of whether he is working on his thesis during this interval. These candidates are also required to be registered for the term in which they graduate.

Other doctoral candidates and master's students may be required to register for a normal credit load because of their appointment status. If not, and if they have earned more than 90 or 30 credits, respectively, and have met the requirements for their degrees except for the completion of the thesis, these students may register for as few as two credits per term. A student who has met the minimum requirements for his degree and is now completing his research and thesis writing off-campus is not required to register, even if he comes to the campus several times each term to see his adviser.

A student, other than one following the new Ph.D. requirements, is not required to register for his final term in order to graduate or in order to make minor revisions to his thesis and/or to take a final examination for his degree.

TIME OF REGISTRATION—Registration days are indicated in the calendar at the beginning of this bulletin.

A student is expected to complete his registration during the officially designated period and to attend the first meeting of all classes in which he is enrolling. If this is impossible because of some emergency or unusual circumstance beyond his control, the student may be granted permission by his instructor to miss a few class meetings, it being understood that work missed will be made up subsequently. Under these conditions the Dean of the Graduate School may grant the student permission to register late. In general, a student who receives permission to register late will be required to reduce his program in proportion to the length of time he has been absent.

Regardless of when he may begin attending classes, a student who fails to complete the process of registration within the officially designated registration period will be liable for the late registration charge.

LOADS, ACADEMIC AND EMPLOYMENT—Many students depend upon part-time employment to help meet their expenses. A student who is thus employed, however, must recognize the time demands of his work schedule in planning his academic program.

The University takes the position that the facilities of the Graduate School should be made available only to students who can profit from their Graduate School experience to a maximum extent. Therefore the Graduate School reserves the right to deny admission or registration to part-time students who (a) propose schedules of few credits which seem to reflect little real interest in graduate work or would not seem to require serious effort, or (b) wish to carry overloads of such proportion as to handicap them seriously in achieving maximum quality in their graduate work.

"Doing graduate work" means more than doing what is required in courses or in research. It means living in a scholarly atmosphere and seriously engaging in scholarly pursuits. It means profiting from hearing visiting scholars and artists and from engaging in dicussions, both formal and informal, with faculty members and fellow

students. It should mean leisure time for reflection and for exploring fields related to, although not directly a part of, one's specialty. Overloads make it difficult and often impossible to do graduate work so conceived. Hence the following "protective" schedule of credit loads for employed students is suggested:

EMPLOYMENT	ACADEMIC LOAD
0 hours per week	8-10 credits
10 hours per week	7- 9 credits
20 hours per week	5- 7 credits
30 hours per week	4- 5 credits
40 hours per week	1- 4 credits

This means, for example, that anyone working twenty hours per week (about half-time) whether as a half-time graduate assistant, as an employee on campus, or as an employee off-campus, may wish to limit the amount of graduate work for which he registers to about three-fifths of a normal full-time load (i.e., to 5-7 credits). The word "employment" is used in a very general sense and includes work for indirect compensation. All students who are thus employed may adjust their academic loads accordingly. Exceptions, in the case of students who have demonstrated unusual ability, must be arranged with the Dean of the Graduate School at the time of registration. (See also Visiting and Auditing Classes.)

A student holding a fellowship, graduate assistantship, or scholarship may not accept employment of any kind for service beyond that specified by his appointment.

VISITING AND AUDITING CLASSES—A graduate student who wishes to attend classes without receiving credit may secure permission either to visit or to audit courses during a term for which he has registered.

As a visitor, a student may attend classes with the approval of the instructor but may not claim the usual privileges of class membership such as participating in discussion, doing practicum work, or taking examinations. He does not register for the privilege of visiting, nor does any record appear on his transcript.

As an auditor, a student may participate in class discussion, do practicum work, take examinations, and generally share the privileges of a class member. The student registers in the same manner as if he were taking the course for credit and pays the same fees. He receives no credit and cannot subsequently secure credit for work done in the course.

A student who, because of his status as a graduate assistant or fellow, is required to register for a certain minimum number of credits is not permitted to count those courses for which he is registering as an auditor for this purpose. The 1G and 2G language courses are an exception. Beyond the required minimum he may register for credit or audit but may not exceed the normal maximum without special permission.

In general, students are encouraged to visit classes rather than to register for a course as auditors. However, visiting is not permitted in German 1G and 2G.

In the 1G and 2G courses offered by the language departments, no distinction is made between registering for credit and for audit in considering loads. If the student does not have a reasonable background in the language, he will be required to count the course as part of his permissible load regardless of whether he registers for credit or for audit. If he has had the language before and is taking the course as a refresher, he may, with the permission of the Graduate Dean, take the course as an overload regardless of whether he registers for credit or audit.

SELECTIVE SERVICE—A request for deferment must be addressed to the local board by the student himself. The University can supply local boards with information needed in support of a request for deferment.

To have his local board informed of his formal admission to the Graduate School,

a student must supply the essential Selective Service information and request the Records Officer to inform the board.

To have his local board informed of his registration and status as a student, a graduate student must request the Records Officer to so inform the local board. If so requested, a report will be sent shortly after the beginning of the first term for which the student registers. A student is certified to be a full-time student insofar as Selective Service is concerned if he schedules at least 8 credits (auditing a course does not count), or if he holds an appointment as a quarter-time or half-time graduate assistant, or if he is serving an internship or holding a traineeship under approved conditions.

If at any time a student changes his status from full-time to part-time, fails to make satisfactory progress, or makes a drastic change in his declared goal, his local board will be notified. If a student changes his status from part-time to full-time and wishes the local board to be informed, he must request the Records Officer to do so. When a student receives a master's degree, it will be assumed his program is terminated, and his board will be so informed unless there is clear prior indication in the Records Office of the student's intention of proceeding with a doctoral program.

GRADING SYSTEM

A grade is given solely on the basis of the instructor's judgment as to the student's scholarly attainment.

The following revised grading system is now in effect: Any one of five quality grades (A, B, C, D, F) may be given a graduate student for course work or for thesis research. The grade point equivalents are 4, 3, 2, 1, 0, respectively.

At the 400, 500, and 600 levels grades of A, B, and C denote graduate credit, whereas D and F are failing grades for graduate students, D being the normal failing grade. A grade of F indicates doubt in the judgment of the instructor of the student's potential for further graduate study.

A minimum grade point average of 3.00 for work done at the University is required for graduation in the case of all candidates whose first registration for graduate study at the University occurred in the spring term 1964 or later.

In addition to the quality grades listed above, two symbols, "Def." (deferred) and "R," may appear on a student's transcript. If work is incomplete at the end of a term for a reason beyond the student's control, or if very little work remains to be done, the instructor may report "Def." in place of a grade, which will appear temporarily on the student's record.

In the case of thesis work, either in progress or completed, and certain courses approved by the University Senate, the instructor may report the symbol "R" in place of a grade. This symbol indicates that the student has devoted an adequate amount of time to the work scheduled but gives no indication of its quality. An "R" remains on the student's transcript permanently. If, after having submitted a series of "R" symbols, the instructor reports a grade of A, B, C, D, or F for a specific term, this grade is considered to apply to the preceding series of registrations and to denote the quality of that entire series.

GRADUATION

It is the responsibility of the student to inform the Graduate Recorder of his intention to graduate (by filing a diploma card) and to pay thesis fees at the beginning of the term in which he expects to receive an advanced degree. If he does not graduate that term, he must reactivate the diploma card by indicating to the Graduate Recorder the term in which he intends to graduate. Deadlines are given in the calendar found at the beginning of this bulletin.

See the *Manual for Graduate Students* for a detailed statement of procedure concerning graduation. Attendance at commencement exercises is expected, but permission to receive the degree in absentia may be granted by the Dean of the Graduate School.

All degrees conferred are tentative until final grade reports have been received, even though the student's name may have appeared in the commencement program.

TUITION AND CHARGES

The University reserves the right to revise the schedule of tuition and charges without further notice.

TOTAL TUITION FOR EACH TERM

University Park Campus—8 or more credits, total charge of $200 for Pennsylvanians and $450 for non-Pennsylvanians; 7 or fewer credits, $22 per credit for Pennsylvanians and $56 per credit for non-Pennsylvanians. These rates also apply to off-campus research and other approved individual study.

Graduate, Medical, and Continuing Education Centers—8 or more credits, total charge of $180 for Pennsylvanians and $450 for non-Pennsylvanians; 7 or fewer credits, $20 per credit for Pennsylvanians and $56 per credit for non-Pennsylvanians.

Vocational Education Programs—7 or fewer credits, $28 per total program for all students (vocational education courses are indicated by "v" following the course number).

Tuition is the same for courses whether audited or taken for credit.

Any student who does not fulfill payment obligations promptly may be charged a late payment fee of $25. A student whose account is delinquent for more than ten days is subject to suspension from the University.

Whenever it appears that an applicant for admission is not domiciled in Pennsylvania, it is assumed that he is a non-Pennsylvanian. If the student who is thus admitted believes that his circumstances do not justify his classification as a non-Pennsylvanian, he may petition the Graduate Dean's office for reclassification.

When a petition for reclassification is made, the petitioner is required to present proof of a bona fide continuous domicile other than as a student of the one admitted (or of his parents, if he is a minor) within the Commonwealth for a period of at least twelve months immediately preceding the date of registration for courses, or such other evidence as is pertinent to a complete review of his classification.

Any student who changes his domicile while attending the University is subject to reclassification effective at the beginning of the first term following notification to the Graduate School that such a change has taken place.

TUITION REFUND POLICY—Charges for tuition are refundable upon withdrawal from the University only in the event the student obtains an Official Withdrawal Form at the office of the Dean of the Graduate School and presents it, together with his current Certificate of Registration, at the office of the Fee Assessor no later than one calendar month after the effective date of withdrawal from classes. Students who meet these conditions are entitled to receive refunds of charges for tuition for the term in accordance with the following schedule:

> Refund of 80 per cent upon withdrawal before the end of the first week of the term (seventh consecutive calendar day from the first day of classes) and a decrease of 20 per cent for each week thereafter up to and including the fourth consecutive calendar week. No amount will be refunded for withdrawal after the fourth consecutive calendar week of the term.

The University will not release any refund of tuition until at least three weeks have elapsed from the date the payment was received. All refunds will be made by check and mailed to the student's home address.

SPECIFIC CHARGES—In addition to the foregoing tuition and charges, the following charges apply under special conditions and are to be paid independently:

Admission to the Graduate School	$ 10.00
Change of schedule, each change	2.00
French reading examination	6.00
Music, individual lessons	30.00 to 100.00
Privilege of late payment	25.00
Privilege of late registration	10.00
Special dissertation fee for Ph.D. candidates (601)	75.00
Special dissertation fee for Ph.D. candidates (611)	25.00
Thesis binding fee for master's candidate	10.50
Thesis microfilming and binding fee for doctoral candidate	45.50
Transcript of records (with seal), each copy	1.00

MOTOR VEHICLE CHARGES—Each graduate student who possesses, maintains, or operates a motor vehicle (including a motorcycle, motor bike, motor scooter, or any other motor-driven vehicle) in Centre County is required to register such vehicle with the Traffic Violations Officer during the registration period of each term. There is no charge for registration for students who do not desire campus driving or parking privileges. Failure to register a vehicle renders a student liable for a fine of $15 for each offense.

A permit allowing limited driving and parking on the campus throughout the week costs $10 per term. A more restricted permit allowing driving and parking on the campus for evenings and weekends costs only $3.50 per term.

A graduate assistant pays no fee for the privilege of driving and parking on the campus but is required to comply with student regulations concerning motor vehicles.

A graduate student planning to operate a motor vehicle in the Centre County area should secure a copy of the leaflet *Parking and Traffic Regulations* from the Traffic Violations Officer.

LIVING ACCOMMODATIONS

Eastview Terrace and Graduate Circle, both located on the eastern side of the campus, provide one- and two-bedroom apartments for married graduate students.

The Eastview Terrace apartments are fire-resistant, one-story, steel framework buildings. Forty-six one-bedroom units rent for $80 per month and thirty-two two-bedroom units rent for $90. Rent includes utilities except for electricity. Water is heated electrically. The units are unfurnished except for electric stove and refrigerator. For each two units, there is a utility room with two stationary laundry tubs and storage space.

Graduate Circle has 144 one-bedroom and 72 two-bedroom apartments in sixteen two-story buildings of brick and frame construction. The units rent for $90 and $100 per month, including all utilities. Each kitchen has a double stainless steel sink with disposal unit, a gas stove, kitchen cabinets, and an electric refrigerator, and each bedroom has a built-in chest of drawers; otherwise the units are unfurnished. There are no facilities for private washing machines in the apartments; however, coin-operated laundries at nominal fees are provided in five of the buildings throughout the area. A storage locker is also provided for each apartment at the laundry location.

Families with children of school age or with children who will become school age during the term of the lease cannot be considered for occupancy in Eastview Terrace and Graduate Circle. The one-bedroom apartments are designed for a husband and wife and the two-bedroom units for a family with not more than two children.

Atherton Hall, located near the Hetzel Union Building and reserved exclusively for single graduate men and women, provides residence hall room accommodations without food service. Double, single, or single occupancy of double rooms are available at $140, $150 and $160 per term, respectively. The Hetzel Union Building cafeteria and snack bar are available for meals.

Separate dining hall meal tickets for one of eight campus dining halls may be purchased for $200 per term. Twenty-one meals per week are served beginning with registration and ending with final examinations.

For application forms and information on apartments and residence or dining halls, contact the Assignment Office for Campus Residences, 101 Shields Building, University Park, Pa. 16802; telephone Area Code 814, 865-7501. Advance application to this office is essential.

Information on other living accommodations available in the community may be obtained through the Chamber of Commerce, 129 W. Beaver Ave., State College, Pa. 16801; telephone Area Code 814, 237-7644. The cost of apartments or rooms in private homes or lodging houses varies considerably, depending upon the type of accommodations desired, and arrangements can best be made by personal visit to the area.

Graduate students should arrange for their accommodations well in advance of the beginning of classes because it may be very difficult to find convenient housing at the last minute. **STUDENTS MUST BE ADMITTED TO GRADUATE SCHOOL BEFORE THEIR REQUEST FOR ON-CAMPUS LIVING ACCOMMODATIONS CAN BE PROCESSED.**

STUDENT SERVICES

HEALTH CENTER—The services and facilities at the Ritenour Health Center are available to full-time graduate students, that is, students registered for eight or more credits or the equivalent (students holding quarter-time assistantships scheduling 7-9 credits, or students holding half-time assistantships scheduling 5-7 credits).

Hospitalized students will be charged $10 per day during confinement. A nominal charge will be made for all drugs dispensed to hospitalized or dispensary patients. Consult the *Manual for Graduate Students* for details concerning facilities and services.

INSURANCE PROTECTION WHILE ATTENDING THE UNIVERSITY—The Pennsylvania State University is an instrumentality of the Commonwealth performing its function of education. It is not liable for the negligence of its officers, servants, and employees when in the exercise of public or governmental powers or in the performance of public or governmental duties incident to the general educational work of the University.

Therefore any student who desires insurance protection while in attendance at the University (1) against personal injury and/or (2) against loss of property by fire or theft should arrange personally for whatever insurance seems advisable.

HEALTH INSURANCE PLAN—A voluntary Accident and Sickness Insurance Plan with a variety of benefits is available to graduate students and their dependents, provided the student is eligible for the services of the Ritenour Health Center. For further information, call the local representative for the student insurance carrier

(telephone Area Code 814, 238-6725), or write to Graduate Student Health Insurance Plan, Graduate School Office, 101 Willard Building, University Park, Pa. 16802.

PLACEMENT SERVICE—The University Placement Service, in cooperation with all the Colleges and departments of the University, assists both graduate and undergraduate students in finding appropriate employment upon graduation. In addition, services are extended to alumni. Among the services offered are: (1) career counseling concerning career planning, career opportunities, employer characteristics, and employment trends; (2) a library of information about employers, employment trends, and career opportunities; (3) the scheduling of interviews with employers visiting the campus; (4) an extended file of employment opportunities for which a student may apply by mail; (5) a listing of summer jobs and internships appropriate to the student's career interests; and (6) conducting of appropriate research. These services are closely coordinated with the Division of Counseling.

Contact is maintained with several thousand employers in education, industry, and government. Information concerning employment opportunities is routinely distributed to all academic departments.

The general placement section concentrates on employment possibilities in industry and government. The educational placement section concentrates on administrative, teaching, and service opportunities in universities as well as in elementary and secondary schools.

RELIGIOUS PROGRAMS—The University seeks to serve the spiritual needs of its students and staff. General responsibility for religious activity on the campus rests with the University Coordinator of Religious Affairs. Individual organizations under the sponsorship of members of the Jewish, Protestant, and Roman Catholic faiths serve the student body. Many other religious organizaions, including denominational and interdenominational groups, are active on the campus and in association with local churches.

STUDENT AFFAIRS—The Graduate Student Association is the official University-wide organization of graduate students. All students have membership in the Association, which promotes the general welfare and the academic interests of graduate students. Members of the Graduate Council or the Graduate Student Association are elected by the council to serve as members of various Graduate School committees. Members of the Graduate Student Association are elected to sit on University Senate committees and have voting power with the committees, but not on the floor of the Senate. The Association publishes the *Graduate School Newsletter,* helps to sponsor the Graduate School lecture series, and sponsors social functions.

MASTER'S DEGREES

The Graduate School recognizes a difference in purpose, which is reflected in the requirements, for two types of advanced degrees, academic and professional. Of the eleven master's degrees conferred, the Master of Arts and the Master of Science are academic in nature. The professional degrees conferred are Master of Administration, Master of Agriculture, Master of Business Administration, Master of Education, Master of Engineering, Master of Fine Arts, Master of Forestry, Master of Public Administration, and Master of Regional Planning.

A degree is not conferred for a mere collection of credits. A well-balanced, unified, and complete program of study will be required, which may frequently exceed the minimum requirements specified below.

A student may meet the degree requirements by either full-time or part-time enrollment and by attendance in any combination of terms. The student who interrupts

the continuity of his registration faces the possibility of not being granted permission to return.

GRADE POINT AVERAGE—A minimum grade point average of 3.00 for work done at the University is required for graduation in the case of all candidates whose first registration for graduate study at the University occurred in the spring term 1964 or later.

TIME LIMITATION—All requirements for a master's degree, whether satisfied on the University Park Campus or elsewhere, must be met within six years or a period spanning seven consecutive summers.

ADMISSION—In addition to the general University requirements for admission set forth at the beginning of this bulletin, adequate undergraduate preparation is required in the field in which the applicant expects to pursue advanced work. The specific courses and the total number of undergraduate credits required in various areas will be determined by the choice of field and can be ascertained from the descriptive statement appearing under the major field heading in the latter portion of this bulletin. An applicant who meets the necessary grade point average but is deficient in course preparation may, under certain circumstances, be admitted to the Graduate School and allowed to make up the undergraduate deficiencies. Under these circumstances the program will require more than the necessary period of residence. An applicant for admission to the M.Ed. program in most major fields is required to have had at least 18 credits in education and related psychology, and in certain major fields may be required to have had practice teaching.

After a student has been admitted to a degree program, he should confer with the head of his major department concerning the appointment of an adviser. The general guidance of a master's candidate is the responsibility of an adviser, or of a committee appointed in a manner to be determined by the major department in which the student is specializing. The adviser or the committee assists the student in planning a program of study. Although the adviser is frequently the supervisor of the thesis, this is not necessarily the case.

Requirements concerning courses, language proficiency, minors, comprehensive examinations, and other matters are sometimes made by departments in addition to (but not in conflict with) the regulations of the Graduate School. For details the student should consult the head of the major department.

TRANSFER CREDIT—Subject to the limitations given below on the use of credits earned away from the University Park Campus, a maximum of 10 credits of high quality graduate work done at another institution may be applied toward a master's degree here.

The student should distinguish carefully between the transferability of credit and its applicability in a particular degree program. When transfer credits are accepted at the time of admission, the student is not really assured of their applicability in his program until he has consulted his adviser and the details of his graduate program have been worked out.

M.A. and M.S.—ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Arts and the Master of Science degrees have similar requirements, the general major area determining which degree is conferred. Programs for both degrees are strongly oriented toward research.

A minimum of 30 graduate credits is required, of which at least 20 must be earned on the University Park Campus or at The Milton S. Hershey Medical Center. A minor is not required of all candidates for M.A. or M.S. degree. A department or committee in charge of a major field may require a candidate to offer work in a minor field, or a student may elect such a program with the permission of his committee.

A minor consists of no fewer than 6 credits of integrated or articulated work in one field related to, but different from, that of the major. A minor program must meet the approval of the departments or committees responsible for both the major and minor fields.

The major department or the committee in charge of the major field is the judge as to the suitability of a field for the minor and of its relevance to the major. The minor department has the responsibility of accepting or rejecting students, advising on courses to be taken by the candidate in its field, examining the candidate in the area of studies he has undertaken in its field, and certifying that the minor requirements have or have not been met.

At least 18 credits in the 500 and 600 series combined must be included in the program. A minimum of 12 credits in course work (400 and 500 series), as contrasted with research, must be completed in the major field. A thesis is required of many candidates for these degrees. Details are given in the introductory paragraphs under the major field headings in the latter part of this bulletin. If a student is required to write a thesis, at least 6 credits in thesis research (600 or 610) must be included in his program. If no thesis is required, at least 18 credits must be in 500 courses.

Those candidates who are not required to write a thesis must present a suitable essay or paper. Its nature and extent shall be determined by the major department. The department shall report to the Dean of the Graduate School the title, the name of the faculty member under whom the student did the work, and whether the work was considered adequate. The department may require one or more copies of such an essay for its library or other files.

A thesis is prepared under the direction of the department in which the candidate's major work is taken. Under certain conditions a student may complete the thesis off-campus. To do so he must make satisfactory arrangements in advance with his adviser and the head of his major department.

A Thesis Information Bulletin, which gives details concerning format, paper, illustrations, and other items, may be obtained at the Graduate School office.

M.Adm.—ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Administration program is designed to meet the professional needs of practicing and potential administrators. A basic premise is that administration is a necessary funcion in all organizations and that it requires a common body of knowledge and skills regardless of its area of application. A total of 30 graduate credits is required—18 in the core courses and 12 in the area of specialization or option—with the majority of the courses at the 500 level. Four option areas are offered: business administration, engineering administration, public administration, and logistics administration. Each student is required to complete a research project in the field or in a laboratory in which he applies research methods and tests his solution through experimentation or simulation. The report must be of the quality, if not the theoretical depth, of a graduate thesis. After substantially completing the course requirements, a candidate must pass a comprehensive written and oral examination administered by a committee of graduate faculty members. The candidate will be expected to demonstrate his ability to integrate knowledge of a specialized area with a broad understanding of the general field of administration.

The program is offered only at the Capitol Campus.

M.Agr.—ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Agriculture is a professional degree. Thus, programs leading to this degree provide opportunities for students to increase their knowledge and competences in the various phases of agriculture. A student, according to his needs, may obtain (1) intensive training encompassing a wide spectrum of subject matter area, or (2) intensive training in a specialized area. The emphasis of the program is to enable students to develop skill as professional practitioners in the communication of technical knowledge and its application to the solution of current and future technical, economic, and social problems of individuals and groups.

The head of the department shall appoint a three-member committee to guide and monitor the candidate's professional development. Members of this committee must represent at least two departments. The chairman of the appointed committee shall serve as the candidate's adviser. Early in his program, the candidate will inform the committee of his background and aspirations. The committee will suggest to the student how best to achieve these goals and the standard of professional competence required for the Master of Agriculture degree.

A minimum of 30 graduate credits is required of which 20 credits must be earned in residence at the University Park Campus. A maximum of 10 credits may be earned in special problem type courses.

The candidate must present an acceptable paper on a selected professional problem, or a report of internship training. Up to 3 graduate credits will be given for an acceptable paper. The candidate may be required to provide one or more copies of the paper for the University.

The candidate's committee shall report through the department head to the Dean of the Graduate School the title of the paper and whether the paper and the candidate's academic performance were considered satisfactory.

M.B.A.—ADDITIONAL SPECIFIC REQUIREMENTS

The purpose of the Master of Business Administration is to develop professional managerial knowledge and skills as these are applied to the decisions in business enterprises. Teaching focuses upon the techniques, the theory, and the skills important to modern administrators.

At least 36 graduate credits are required of which 18 or more are to be completed at the 500 level and 26 hours at University Park. Candidates who are admitted without an undergraduate business background may be required to undertake up to 30 hours of work preparatory to full status as a M.B.A. candidate. During the later stages of course work, some specializations within a major area of student interest and a M.B.A. project paper are undertaken. Applications must include the results of the Admission Test for Graduate Study in Business sent directly from the Educational Testing Service.

M.Ed.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Education provide preparation for increased professional competence in the several fields of education. They should be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Arts or Master of Science. In most major fields the requirements for admission include 18 credits in education and related psychology.

MASTER'S DEGREES

A minimum of 30 graduate credits is required for the degree, of which at least 20 must be earned on the University Park Campus; at least 24 must be in course work.

MAJORS IN THE FIELDS OF EDUCATION—A student may major in one of the approved fields of education, such as elementary education, art education, or home economics education, and proceed under the guidance of the appropriate department of education.

A program of this type requires at least 6 credits to be earned outside the fields of education.

MAJORS OUTSIDE THE FIELDS OF EDUCATION—A student who is preparing to teach in a specific subject-matter field, such as geography, mathematics, or German may choose such a field as his major and take the majority of his work in it under the guidance of the department offering that major. A student wishing to work in a broader area may choose a major such as biological science, earth sciences, physical science, or social studies and take at least 24 credits in the area under the guidance of the committee in charge of the major.

Each candidate is required to earn 6 credits in education as directed by the faculty of one of the approved graduate programs in education. The 6 credits may be taken in educational foundations, which includes courses in comparative education; history, sociology, and philosophy of education; and educational psychology.

THESIS OR PAPER—Six credits may be granted for an approved thesis. A candidate who does not elect to write a thesis is required to present an essay or paper. It must be of considerable proportion, indicating capacity to describe a serious intellectual experience adequately in writing, and giving unmistakable evidence of ability to formulate and state meaningfully the purpose of an investigation, study, critical analysis, or evaluation; to acquire and analyze information; to draw conclusions logically; and to relate findings to professional problems and practices. The nature and extent of such a piece of writing, whether it be required in connection with a course or independently of course work, and when it is to be undertaken shall be determined by the major department. The department shall report to the Dean of the Graduate School the title, the name of the faculty member under whom the student did the work, and whether the work was considered adequate. It is the right, but not the responsibility, of the department to require one or more copies of such an essay for its library or other files.

M.Eng.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Engineering provide training for advanced professional competence in the several fields of engineering. They should be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Science.

A minimum of 30 graduate credits is required, of which at least 12 must be earned in graduate courses (500 series).

A scholarly written report on a developmental study involving at least one area represented in the candidate's course work is required as an integral part of the program. The report must be comparable in its level of work and quality to a graduate thesis. The topic of the developmental study is subject to prior approval by the department in which the candidate's major work is taken, and preparation of the written report shall be under the direction of that department.

No work for this degree is required to be done specifically on the University Park Campus provided the major department or supervisory committee and the Dean of

the Graduate School agree that a complete program of study can be pursued at an established Graduate Center of The Pennsylvania State University.

M.F.A.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Fine Arts provide training for increased professional competence in the several specialized areas of the arts. They should be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Arts with a major in art, music, or theatre arts.

A minimum of 48 credits is required, of which at least 38 must be earned on the University Park Campus. The larger part of these credits should be above the 400 level, but the needs of the student shall be considered in arranging the best combination of courses and research for the preparation of the candidate in his particular field.

A professional project, either creative or interpretative, is required. This project shall include a monograph in support of the creative or interpretative aspect; such monograph shall represent a minimum of 6 credits on the 600 level.

M.F.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Forestry provide training for increased professional competence in the several specialized areas of forest resource management and forest products. They should be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Science with a major in forest resources.

A minimum of 30 graduate credits is required, of which at least 20 must be earned on the University Park Campus.

A candidate for the degree of Master of Forestry should choose one area for his major and one or two related areas for his minor. The proportion of credits to be taken in the major and minor fields of study will be determined in consultation with the student's advisory committee. It is expected that the larger part of the program shall be in graduate courses (500 series), but no specific number of credits in the 500 series is required.

Each candidate is required to submit an acceptable thesis based on at least 6 credits of thesis research.

M.P.A.—ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Public Administration is a professional degree for students who are planning careers in public administration in local, state, and national governmental jurisdictions, or in international, private, or voluntary agencies. This program should be distinguished from the research-oriented program which leads to the academic degree of Master of Arts with a major in political science in which the candidate may specialize in public administration.

For the M.P.A. degree a minimum of 30 graduate credits is required, with the greater portion of the courses being at the 500 level. An M.P.A. essay or paper will also be required but will carry no graduate credit. A comprehensive final examination will be given to all candidates.

No work for this degree is required to be done specifically on the University Park Campus provided the major department or supervising committee and the Dean of the Graduate School agree that a complete program of study can be pursued at an established Graduate Center of The Pennsylvania State University.

The degree is a terminal one, and credits earned in the program may or may not be applicable, even in part, toward a doctorate.

M.R.P.—ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Regional Planning is a professional degree for students interested in a coordinated attack on the problems of community development and resource management. The program is intended to acquaint the student with rational programs of spatial allocation of land uses and facilities, maintenance of cultural and aesthetic values, and legal and governmental techniques for their implementation.

A minimum of 45 graduate credits is required. At least 36 credits are required in planning courses, of which 9 will be devoted to a group regional planning project or a problem-oriented thesis. A student who does not submit a thesis will present a project report, comparable in quality and scope to a graduate thesis.

This degree is also offered at the Capitol Campus Graduate Center.

DOCTORAL DEGREES

The Doctor of Philosophy, an academic degree, and the Doctor of Education, a professional degree, are conferred by the University. Recognized as different in purpose, the two programs consequently have different requirements in certain respects.

ADMISSION—A student who has been admitted to the Graduate School and has been accepted by the department or committee in charge of a major field in which the doctorate is offered may begin working toward a doctor's degree. However, he has no official status as a doctoral student and no assurance that he will be accepted as a doctoral candidate until he has passed a candidacy examination. This examination is administered by the major department and is given early in the student's program.

GENERAL REQUIREMENTS—No specified number of courses completed or credits earned will assure attainment of the doctorate. The general requirements are based upon a period of residence, the writing of a satisfactory thesis, and the passing of a comprehensive and a final oral examination. A doctoral program consists of such a combination of courses, seminars, and individual study and research as meets the minimum requirements of the Graduate School and is approved by the doctoral committee for each individual student.

A master's degree is not a prerequisite for the doctorate. However, the first year of graduate study leading to the Ph.D. may be substantially the same as that provided for the M.A. or M.S. degree. Similarly the first year of the D.Ed. program may be essentially the same as that provided for the M.Ed.

GRADE POINT AVERAGE—A minimum grade point average of 3.00 for work done at the University is required for admission to the comprehensive examination and for graduation in the case of all candidates whose first registration for graduate study at the University occurred in the spring term 1964 or later.

TIME LIMITATION—A student who was formally accepted as a doctoral candidate on or after June 1, 1963, is required to complete his program within seven years from the date of his acceptance as a candidate. A student who was admitted to doctoral candidacy, formally or informally, prior to June 1, 1963, is required to complete his program before July 1, 1971.

OFF-CAMPUS AND TRANSFER CREDITS—Subject to the approval of his adviser and the head of his major department, a student may register for research to be done away from the University Park Campus.

With the approval of his committee, a candidate may apply toward the minimum requirements of a doctor's degree a maximum of 10 credits earned in Continuing Education classes or at the Commonwealth Campuses of The Pennsylvania State University. Credits so earned as a part of a master's degree program must be included in the limit of 10.

A maximum of 30 credits beyond the baccalaureate at an approved school not granting the doctorate in the student's major field may be accepted by the Graduate School in partial fulfillment of the requirements for a doctoral degree at The Pennsylvania State University. A maximum of two full academic years of work (60 credits) beyond the baccalaureate at a graduate school which grants the doctorate in the candidate's major field may be accepted here to apply toward doctoral degree requirements. Work beyond the master's will not be transferred if taken more than five years before beginning work for the doctorate at Penn State. Credits transferred will apply toward meeting degree requirements only if judged by the doctoral committee to be appropriate to the candidate's program of study.

ADVISERS AND DOCTORAL COMMITTEES—After a student has been admitted to a degree program, he should confer with the head of his major department concerning departmental procedures and the appointment of an adviser. Arrangement and approval of the details of the student's term-by-term schedule is the function of the adviser. This person may be a member of the doctoral committee or someone else designated by the head of the major department for this specific duty.

General guidance of a doctoral candidate is the responsibility of a doctoral committee consisting of four or more members of the Graduate Faculty. One member shall be from outside the candidate's major field. It is appointed by the Dean of the Graduate School, upon recommendation of the head of the major department, after the student is admitted to candidacy. At his discretion, the Dean may add other members to the committee. The supervisor of the candidate's thesis will usually, but not necessarily, be designated as chairman. The chairman must hold senior membership in the Graduate Faculty. An associate member may not exclusively supervise the research for a doctoral candidate, but he may serve with a senior member as co-chairman of the committee.

The doctoral committee is responsible for establishing the broad outline of the student's program and should review the program as soon as possible after his admission to candidacy. It will prepare, give, and evaluate the candidate's examinations, and supervise and approve his thesis. A favorable vote of at least two-thirds of the members of the committee is required for passing a comprehensive or a final oral examination. If a candidate fails an examination, it is the responsibility of the doctoral committee to determine whether he may take another examination.

The committee will also notify the Dean when the candidate is ready to have his comprehensive and his final oral examination scheduled and will report the results of these examinations to the Dean.

LANGUAGE AND COMMUNICATION COMPETENCE—A candidate for the degree of Doctor of Philosophy is required to demonstrate high-level competence in the use of the English language, including reading, writing, listening, and speaking. Proficiency is expected at the time of admission to the Graduate School and must be achieved before admission to candidacy.

In addition to demonstrating competence in English, each candidate for the Ph.D. must meet the language and communication requirement for foreign language(s) which has been established by his major department with the approval of the Graduate School Committee on Languages and Communications.

If a candidate is to be examined for a reading knowledge of a foreign language by one of the language departments, he must report his intention to take the examination to the secretary of the language department by the end of the first week of classes for the term during which he wishes to take it, except in the case of French or Spanish. This date is one week prior to the examination date. The examination will be administered on dates announced in the graduate calendar at the beginning of this bulletin.

Candidates for the D.Ed. degree may be required to demonstrate competency in foreign languages.

CANDIDACY EXAMINATION—This examination is administered by the major department and should be taken early in the student's program. For the Ph.D. student following the new requirements, the examination may be given after he has earned at least 12 credits in graduate courses beyond the baccalaureate. He must take the examination not later than three terms after earning 24 credits.

For all other Ph.D. and D.Ed. students, the examination should be given when the student has earned a total of approximately 30 credits, including his master's program and work done elsewhere. A student transferring from another graduate school with 30 or more transfer credits must be given the candidacy examination before he has earned more than 10 credits here.

COMPREHENSIVE EXAMINATION—When a candidate for the Ph.D. or D.Ed. degree has substantially completed his course work, he is required to take a comprehensive examination covering his major and minor fields of study.

A candidate for the Ph.D. must have satisfied the language and communication requirements before taking the examination.

All candidates whose first registration for graduate study at the University occurred in the spring term 1964 or later are required to have a minimum grade point average of 3.00 for work done at the University at the time the comprehensive examination is given.

The examination is officially scheduled and announced by the Dean of the Graduate School upon recommendation of the doctoral committee. It is given and evaluated by the doctoral committee and may be either written or oral, or both. A favorable vote of at least two-thirds of the members of the committee is required for passing. In case of failure it is the responsibility of the doctoral committee to determine whether the candidate may take another examination. The results are reported to the Dean of the Graduate School, and will be entered on the candidate's official record.

When a period of more than five years has elapsed between the passing of the comprehensive examination and the completion of his program, the student is required to pass a second comprehensive examination before the final oral examination will be scheduled.

FINAL ORAL EXAMINATIONS—The doctoral candidate who has satisfied all other requirements for the degree will be scheduled by the Dean of the Graduate School, on recommendation of the doctoral committee, to take a final examination. Normally the final oral examination may not be scheduled until at least three months have elapsed after the comprehensive examination was passed, although the Graduate Dean may grant a waiver in the case of an outstanding student. The deadline for holding the examination is seven weeks before Commencement.

The final examination is oral, open to the public, and related in large part to the thesis; but it may cover the candidate's whole field of study without regard to courses that have been taken either here or elsewhere.

A favorable vote of at least two-thirds of the members of the committee is required

for passing. The results of the examination are reported to the Dean of the Graduate School and will be entered upon the candidate's official record. If a candidate fails, it is the responsibility of the doctoral committee to determine whether he may take another examination.

Ph.D.—ADDITIONAL SPECIFIC REQUIREMENTS

The degree of Doctor of Philosophy is conferred in recognition of high attainment and productive scholarship in some special field of learning as evidenced by (1) the satisfactory completion of a prescribed period of study and investigation, (2) the preparation of a thesis involving independent research, and (3) the successful passing of examinations covering both the special subject and the general field of learning of which this subject forms a part.

In the fall term 1967 a revised set of requirements for the Ph.D. went into effect. A student who, by the end of the summer term 1967, had earned 45 or fewer graduate credits which were applicable toward his degree follows the new requirements.

RESIDENCE REQUIREMENTS—There is no required minimum of credits or terms of study, but over some twelve-month period during the interval between admission to candidacy and completion of the Ph.D. program the candidate must spend at least three terms (which may include the term in which the candidacy examination is taken) as a registered student, during which time he is engaged in full-time academic work on the University Park Campus or at The Milton S. Hershey Medical Center *and* is certified by his department as devoting half time or more to graduate studies and/or thesis research to meet his degree requirements.

After a student has passed the comprehensive examination and met the three-term requirement described in the preceding paragraph, no further registration for credit will be required by the Graduate School. He shall, however, maintain his status as a student by registering continuously (at least three terms per calendar year) until the thesis is accepted by his doctoral committee. This registration may be for courses for credit, for 601, or for 611, the latter two involving no credit and no tuition.

OLD RESIDENCE REQUIREMENTS—A student who had earned more than 45 credits by the end of the summer term 1967 will be required to span a minimum of nine terms in full-time graduate study and research (10 credits per term), or their equivalent in credits (90 credits), for the Ph.D. At least 30 credits must be earned in residence at the University Park Campus.

For a period of three terms, two of which must be consecutive, the Ph.D. candidate must limit his work load to half-time at most, the balance of his time being devoted to graduate study.

A graduate assistant or research assistant who is a candidate for the doctorate, has passed the comprehensive examination, is registered for the maximum allowable credit load, and is certified by his department as devoting all his time to studies and thesis research to meet his degree requirements may be regarded by the Dean of the Graduate School as a full-time student for a period not exceeding one calendar year. Such a student will be considered to earn the equivalent of 10 credits per term, and three such terms will meet the minimum residence requirement for the Ph.D.

MINOR FIELDS—A Ph.D. candidate is not required by the Graduate Faculty to have a minor field of study. However, a department or a committee in charge of a major field may require a candidate to offer work in a minor field, or a student may elect such a program with the permission of his doctoral committee.

A minor consists of no fewer than 15 credits, including those applied toward the

master's degree, of integrated or articulated work in one field related to, but different from, that of the major. A minor program must meet the approval of the departments or committees responsible for both the major and the minor fields.

THESIS—The ability to do independent research and competence in scholarly exposition must be demonstrated by the preparation of a thesis on some topic related to the major subject. It should represent a significant contribution to knowledge, be presented in a scholarly manner, reveal an ability on the part of the candidate to do independent research of high quality, and indicate considerable experience in using a variety of research techniques. The contents and conclusions of the thesis must be defended at the time of the final oral examination.

The completed thesis, together with three separate copies of an abstract, must be filed in the office of the Dean of the Graduate School not later than five weeks prior to the commencement at which the candidate expects to receive the degree.

A *Thesis Information Bulletin,* which gives details concerning format, paper, illustrations, and other items, may be obtained at the Graduate School office.

D.Ed.—ADDITIONAL SPECIFIC REQUIREMENTS

Programs leading to the degree of Doctor of Education are not limited to specific fields of education but, with the consent of the department or committee in charge, may also be offered in any other field appropriate to the preparation of teachers which has been approved for the doctorate, e.g., biological science, foods and nutrition, or English.

The degree is conferred in recognition of advanced preparation of a high order for work in the profession of education as evidenced by (1) satisfactory completion of a prescribed period of study; (2) ability to apply scientific principles in classroom instruction, supervision of instruction, administration, or as a consulting specialist in certain educational areas; (3) preparation of a thesis demonstrating ability to undertake an educational problem with originality and independent thought; and (4) successfully passing examinations, i.e., showing a satisfactory grasp of the field of specialization and its relation to allied educational areas.

RESIDENCE REQUIREMENTS—A minimum of nine terms of full-time graduate study and research (10 credits per term), or their equivalent in credits (90 credits)—of which at least 30 credits must be earned in residence at the University Park Campus or The Milton S. Hershey Medical Center—is required for the D.Ed. degree. The D.Ed. candidate may meet the requirements by attending summer terms unless his major department requires a period of registration in other terms or in consecutive terms at University Park. A candidate may register for a maximum of 30 credits of research in absentia, but none of these may count toward the minimum of 30 credits which he is required to earn on the University Park Campus or at The Milton S. Hershey Medical Center. The maximum credit load permitted a student who is employed full time is 4 credits per term.

MAJOR AND MINOR FIELDS—The program of study includes a major and either a minor or a group of general studies. A majority of the courses offered in fulfillment of the requirements must be in the major field of study.

A candidate choosing a major outside the fields of education (such as speech, geography, or history) shall have a minor consisting of no fewer than 15 credits, including those applied toward the master's degree, in educational foundations, which includes courses in comparative education, educational measurements and statistics, educational psychology, history of education, and philosophy of education.

A candidate choosing a major in one of the fields of education must also choose either a minor or a group of general studies with the approval of the major department. In this case a minor consists of no fewer than 15 credits, including those applied toward the master's degree, in one field outside those of education. An acceptable general studies group consists of no fewer than 15 credits, including those applied toward the master's degree, in fields outside those of education considered by the major department to have significance and value for the candidate.

COMPREHENSIVE EXAMINATIONS—In addition to demonstrating a high level of competence in the subject matter of his major and minor fields, each candidate must show in his comprehensive examination that he is familiar with current theories of education; that he understands and can apply the techniques and the findings of educational research so far as they bear upon the teaching of his subject; that he is prepared to read understandingly and contribute to the technical and professional literature in his field; and that he can criticize his own procedures in the light of historical trends and practices in this and other countries. Command of the tools for a thorough study of the problems of education is necessary and must include familiarity with statistical methods. For certain students the requirements may include a reading knowledge of one or more foreign languages.

All candidates whose first registration for graduate study at the University occurred in the spring term 1964 or later are required to have a minimum grade point average of 3.00, for work done at the University, at the time the comprehensive examination is given.

THESIS—Evidence of a high degree of scholarship, competence in scholarly exposition, and ability to select, organize, and apply knowledge must be presented by the candidate in the form of a written thesis. The candidate must demonstrate a capacity for independent thought as well as ability and originality in the application of educational principles or in the development of new generalizations under scientific controls. A thesis may be based upon a product or project of a professional nature, provided scholarly research is involved. For example, it may be based upon the solution of a professional problem concerned with the development of a curriculum, or a product of creative effort related to education. However, in order to be acceptable as a thesis, the professional project must be accompanied by a written discourse demonstrating the nature of the research and including such theories, experiments, and other rational processes as were used in effecting the final result. The topic and outline of the proposed thesis must have the approval of the doctoral committee.

The completed thesis, together with three separate copies of an abstract, must be filed in the office of the Dean of the Graduate School not later than five weeks prior to the commencement at which the candidate expects to receive the degree.

A *Thesis Information Bulletin*, which gives details concerning format, paper, illustrations, and other items, may be obtained at the Graduate School office.

STUDENT AIDS

In every case in which a graduate assistantship, fellowship, grant-in-aid, or scholarship for the next academic year is offered to an actual or prospective graduate student, the student, if he indicates his acceptance before April 15, will have complete freedom through April 15 to submit in writing a resignation of his appointment in order to accept one elsewhere. However, an acceptance given or left in force after April 15 commits him not to accept another appointment without first obtaining formal release for the purpose.

STATEMENT OF NONDISCRIMINATION

In the selection of individuals for all types of financial aids for graduate study, in which the University has partial or complete control of the selection process and administration of the program, the University will not discriminate on the basis of race, creed, color, or national origin of any applicant.

ASSISTANTSHIPS

Approximately 1,900 graduate assistantships are awarded annually. Most of these are half-time, but a limited number of quarter-time and three-quarter-time assistantships are available in some departments. An appointee may serve as an assistant in classroom or laboratory instruction, or in research or other work.

A prospective student should write directly to the head of his major department for information and application forms. Appointments are made upon the recommendation of the department head, subject to the student's admission to the Graduate School. Clear evidence of superior ability and promise is required. Reappointment to an assistantship requires a continuing demonstration of good scholarship.

The assistantships vary as follows:

QUARTER-TIME—The student may schedule 7-9 credits, receives a stipend in the range $270-$480 plus a grant-in-aid which covers tuition, will be required to give a maximum of ten hours of service per week for twelve weeks, and will be considered to be following a full-time course of instruction under Selective Service regulations.

HALF-TIME—The student may schedule 5-7 credits, receives a stipend in the range $480-$1,020 plus a grant-in-aid which covers tuition, will be required to give a maximum of twenty hours of service per week for twelve weeks, and will be considered to be following a full-time course of instruction under Selective Service regulations.

THREE-QUARTER-TIME—The student may schedule 4-5 credits, receives a stipend in the range $810-$1,350 plus a grant-in-aid which covers tuition, will be required to give a maximum of thirty hours of service per week for twelve weeks, and will be considered a part-time student.

The credit load limits specified above may be increased or decreased for a specific term by arrangement with the Dean of the Graduate School, provided the credit load and the service load are properly balanced in each term and the total credit load over a series of terms is in conformity with the specified limits.

In addition to receiving a grant-in-aid to cover full tuition during the term of appointment, a graduate assistant who is completing three or more consecutive terms of service is entitled to apply for an extra earned grant-in-aid to cover tuition for the succeeding term without service if he is not receiving a scholarship or fellowship from another source during the term. To receive this privilege a student must obtain an extra earned grant-in-aid form from the head of the department in which he has held the assistantship and must follow the instructions on the form in making application.

A graduate assistant may not accept employment, either at the University or elsewhere, during the period for which service to the University is required under the appointment (twelve weeks per term).

A graduate assistant pays no fee for the privilege of driving and parking on the campus but is required to comply with student regulations concerning motor vehicles.

FELLOWSHIPS AND TRAINEESHIPS

More than five hundred fellowships and traineeships are awarded annually. Recipients must be superior students and are frequently required to have completed a certain minimum of graduate work before being eligible for an award. Fellows and trainees carry full-time graduate programs, receive stipends which vary with the awards, and usually receive grants-in-aid paid by the donors of the awards to provide for all tuition. They may not accept employment during the terms of their appointments (except when stipulated for training purposes in certain foundation and federal fellowship and traineeship programs), nor are they required to render any service to the University. In some cases a recipient will be expected to limit his research to a broad field specified by the donor. Recipients are required to pay specific charges, such as admission, late registration, change of schedule, and parking fees, and also the thesis binding and microfilming fee unless the latter is paid for by the donor of the award.

GRADUATE SCHOOL FELLOWSHIPS—A small number of fellowships, each paying a stipend of $2,520 for the fall, winter, and spring terms and providing a grant-in-aid to cover all tuition charges for these terms, are given by the University and are designated as Graduate School Fellowships. They are available to outstanding graduate students working toward a doctorate degree in any field, although, ability of applicants being comparable, some preference is given to students majoring in the humanities and social sciences.

Applications should be addressed to the Dean of the Graduate School and must be received by February 8 to be considered for the following year.

FELLOWSHIPS AND TRAINEESHIPS FROM SPECIFIC GRANTS TO DEPARTMENTS AND DIVISIONS BY FOUNDATIONS, INDUSTRIES, AND FEDERAL AGENCIES—At least 230 such awards, with various stipends are granted through individual departments. Information and application forms may be secured from the head of the major department concerned. The specific awards will vary somewhat from year to year, but the following are typical of those which were available for 1969-70.

Accountants Fund, Inc., Dissertation Fellowship—Available to a Ph.D. candidate in business administration who is preparing to teach accounting; stipend variable up to $5,000.

Airco-Speer Carbon Fellowship—Available to a graduate student in fuel science for studies on carbon; stipend $2,680-$3,500.

Amelia Earhart Fellowship—Available to a woman graduate student in aerospace engineering; stipend $2,400.

American Chemical Society Fellowships (2)—Available to graduate students in chemical engineering; stipend $2,430.

American Chemical Society Fellowships (2)—Open to graduate students in geochemistry, mineralogy, and solid state science; stipend $2,400.

American Cyanamid Fellowship in Chemistry—Available to a graduate student in chemistry for the final year of study leading to the Ph.D. degree; stipend $1,800.

American Iron and Steel Institute Fellowships (2)—Open to graduate students in geochemistry and metallurgy; stipend $2,400-$4,320.

Armstrong Cork Fellowship in Business Administration—Available to a Ph.D. candidate in business administration; stipend $4,000.

Armstrong Cork Summer Fellowships in Chemistry (5)—Open to graduate students in chemistry; stipend $640.

Atomic Energy Commission Graduate Traineeships in Nuclear Reactor Operations and Utilization (6)—Open to graduate students in nuclear engineering; stipends comparable to the AEC Special Fellowships.

AUTOMOTIVE SAFETY FOUNDATION FELLOWSHIPS—Open to engineering graduates for graduate study in highway traffic engineering. Only U. S. citizens are qualified. Fellowships include tuition and living stipend of $2,340 for the nine-month course starting each fall term.

CARBORUNDUM CORPORATION FELLOWSHIP—Available to a graduate student in mineral preparation; stipend $2,400.

CONTINENTAL OIL COMPANY FELLOWSHIP—Available to a graduate student in chemical engineering; stipend $2,325.

CONTINENTAL OIL COMPANY FELLOWSHIP—Available to a graduate student in petroleum and natural gas engineering for studies in petroleum engineering; stipend $2,280.

CONTINENTAL OIL COMPANY FELLOWSHIP IN PETROLEUM ECONOMICS—Available to a graduate student in mineral economics for studies in petroleum economics; stipend $2,280.

DEAN'S FELLOWSHIPS IN BUSINESS ADMINISTRATION—Available to doctoral candidates with interests in teaching and research, combined with a third year graduate assistantship; stipend $4,000 per year plus tuition.

DIAMOND SHAMROCK CORPORATION FELLOWSHIP—Available to a graduate student in chemical engineering; stipend $2,325.

DU PONT SUMMER FELLOWSHIPS (6)—Open to graduate students in chemical engineering; stipend $600.

W. S. ELLIOTT FELLOWSHIP—Available to a graduate student who is a Penn State graduate and is interested in engineering research; stipend $1,200.

ERIE TECHNOLOGICAL PRODUCTS FELLOWSHIP—Available to a graduate student in metallurgy; stipend $3,120 per year.

ERNST AND ERNST FELLOWSHIP—Available to a master's candidate in accounting; stipend $1,000.

ESSO RESEARCH AND ENGINEERING FELLOWSHIP IN CHEMISTRY—Available to an advanced graduate student for one year of study leading to the Ph.D. degree; stipend $1,800-$2,200.

FISHER-PRICE FELLOWSHIP—Available to an advanced graduate student in child development and family relationships and especially interested in work with young children; stipend $3,500 for tuition and other expenses.

GENERAL FOODS FUND FELLOWSHIPS (2)—Open to graduate students with a major in the College of Human Development; stipend for doctoral $3,000, for master's $2,000 for tuition and other expenses.

GULF OIL COMPANY FELLOWSHIP IN PETROLEUM AND NATURAL GAS ENGINEERING—Available to a graduate student for work in petroleum production; stipend $2,400.

GULF OIL CORPORATION FELLOWSHIP—Available to a graduate student in chemical engineering; stipend $2,500.

HAMILTON STANDARD FELLOWSHIP—Available to a graduate of the University in aerospace, electrical, and mechanical engineering, engineering mechanics, or physics; stipend $1,800.

HASKINS AND SELLS FOUNDATION FELLOWSHIP—Available to a graduate student in accounting; stipend $2,500.

H. R. IMBT SERVICES, INC., FELLOWSHIP—For graduate work in civil engineering in the field of civil engineering construction; stipend $3,000.

INSURANCE INSTITUTE FOR HIGHWAY SAFETY—Open to engineering graduates for graduate study in highway traffic engineering. Only U. S. citizens are qualified. Fellowships include tuition and living stipend of $2,340 for the nine-month course starting each fall term.

INTERNATIONAL BUSINESS MACHINES CORPORATION FELLOWSHIP—Available to an outstanding advanced graduate student in materials science when his doctoral research is amenable to treatment by a digital computer; stipend $3,000-$4,800. Apply to the Dean of the Graduate School.

INTERNATIONAL LEAD ZINC RESEARCH ORGANIZATION FELLOWSHIP—In support of

research on the application of lead and zinc compounds to chemical, ceramic, electrical, and allied industries. Available to a student in ceramic science; stipend $3,000.

International Lead Zinc Research Organization Fellowship—In support of research on the physics and chemistry of lead and zinc compounds. Available to a student in solid state science; stipend $2,540.

Joseph M. Johnston Memorial Scholarship—Available to a student whose program is related to floriculture; stipend variable.

Marathon Oil Company Fellowship—Available to a graduate student in petroleum and natural gas engineering; stipend $2,280.

Mobil Fellowship—Available to a graduate student in chemical engineering; stipend $3,000-$3,500.

National Lead Company, Titanium Alloy Manufacturing Division Fellowship—In support of research on the chemistry and physics of titanium and zirconium compounds of interest to the chemical and ceramic industries; stipend $2,600.

National Science Foundation Academic Year Institute Participant Support—Open to pre-doctoral, pre-service teachers with undergraduate degrees in engineering, physical science, or mathematics. Participants must indicate their intentions to enter teaching at technical institute or junior college level; stipend $2,400 for 12 months, plus dependency allowance not to exceed $1,500.

National Steel Corporation Fellowship—Available to a graduate student in metallurgy; stipend $2,880.

Norton Company Fellowship—Available to a graduate student in ceramic science for research on thermal/mechanical properties; stipend $3,000.

Edward Orton, Jr., Ceramic Foundation Fellowship—Available to a student in ceramic science for studies relating to kiln-dried ceramic materials; stipend $2,400.

Pennsylvania Cooperative Fishery Unit Fellowships (3-4)—Open to graduate students in zoology; stipend $2,400-$2,460.

Pennsylvania Cooperative Wildlife Research Unit Fellowships (4)—Open to graduate students in forestry, zoology, and related fields; stipend $2,400.

Pennsylvania Electric Association Fellowship—For graduate work in mineral economics on potential markets for fly ash; stipend $2,400.

Pennsylvania Environmental Engineering and Science Fellowships—Available to graduate students in environmental studies; $5,400 for stipends, plus tuition and related fees.

Pennsylvania Natural Gas Men's Fellowship—Available to a graduate student in petroleum and natural gas engineering for studies in gas technology; stipend $2,000.

Price Waterhouse Foundation Fellowship—Available to a Ph.D. candidate in accounting; stipend variable up to $5,000.

Radio Corporation of America Fellowship—Available to a graduate student in electrical engineering; stipend $2,100-$3,000 for nine months. May be supplemented for an additional three months on application.

Shell Companies Foundation Fellowship—Open to advanced graduate students in two of these fields in rotation: chemical engineering, chemistry, and petroleum engineering; stipend $2,500.

Shubert Fellowship in Playwriting—Available to a graduate student in theatre arts; stipend $2,500.

Edwin Earle Sparks Dissertation Fellowship in the Humanities (1)—Available to doctoral candidate in the humanities (classics, English, French, German, history, philosophy, religious studies, Slavic languages, Spanish, Italian and Portuguese, speech); stipend $3,500 plus tuition. Apply to relevant department.

Edwin Earle Sparks Fellowships in the Humanities (8)—Available to graduate students in the humanities (classics, English, French, German, history, philosophy, religious studies, Slavic languages, Spanish, Italian and Portuguese, speech); stipend $2,000 plus tuition. Apply to relevant department.

Stackpole Carbon Fellowship—Available to a graduate student in fuel science for studies on carbon; stipend $3,600.

Stackpole Ferrite Fellowship—Available to a graduate student in ceramic science or solid state science; stipend $3,000.

FELLOWSHIPS

STAUFFER CHEMICAL COMPANY FELLOWSHIP IN CHEMISTRY—Available to a graduate student in chemistry for research on organometallic compounds; stipend $1,800.

SUN OIL COMPANY FELLOWSHIP IN CHEMISTRY—Available to the incoming graduate student who is judged to offer the greatest promise for a successful career in chemistry; stipend $3,000.

SURFACE COMBUSTION FELLOWSHIP—Available to a graduate student in fuel science for studies in the field of gaseous combustion; stipend $3,600.

TEXACO FELLOWSHIP IN ENVIRONMENTAL STUDIES—Available to a graduate student in environmental studies; stipend $3,000 per year plus tuition.

TEXACO FELLOWSHIP IN GEOPHYSICS—Available to a graduate student in geophysics; stipend $2,760.

UNION CARBIDE FELLOWSHIP—Available to a graduate student in mechanical engineering; stipend $2,430 per year (three terms).

UNION CARBIDE SUMMER FELLOWSHIPS (5)—Available to a graduate student in chemical engineering; stipend $600.

U. S. OFFICE OF EDUCATION EXPERIENCED TEACHER FELLOWSHIPS IN GEOGRAPHY (15)—Open to secondary school teachers with at least one year of experience, preferably three years, who are released from their school systems and promise to return after the year's study; stipend $4,000 plus dependency allowance.

U. S. OFFICE OF EDUCATION FELLOWSHIPS—Open to graduate students with undergraduate degree in engineering, physical science, or mathematics who are preparing for technology teachers in technical institutes and junior colleges; stipend $2,400 for 12 months plus an allowance of $500 for each dependent.

U. S. OFFICE OF EDUCATION FELLOWSHIPS IN EDUCATION OF EXCEPTIONAL CHILDREN (28)—Open to graduate students being prepared as leadership personnel in the education of the mentally retarded and the emotionally disturbed and in special education administration; stipend $2,200-$3,200 plus dependency allowance. Apply to the head of the Department of Special Education.

U. S. OFFICE OF EDUCATION FELLOWSHIPS FOR PROSPECTIVE AND EXPERIENCED TEACHERS IN OUTDOOR EDUCATION (12)—Open to teachers, grades K-6, with at least one year experience and to those persons who plan to go into elementary school teaching; open nationally; 12 month program; stipend for teachers with at least one year experience $4,000 plus dependency allowance plus tuition plus $800 for summer term; stipend for prospective teachers with no experience $2,000 plus dependency allowances plus tuition plus $400 for summer term.

U. S. OFFICE OF EDUCATION FELLOWSHIPS IN SPEECH PATHOLOGY AND AUDIOLOGY: WORK WITH THE SPEECH-HANDICAPPED (5); WORK WITH THE DEAF (4)—Open to graduate students specializing in these fields; stipend $2,200-$3,200 plus dependency allowance. Apply to the director of the Speech and Hearing Clinic.

U. S. OFFICE OF EDUCATION PROSPECTIVE TEACHER FELLOWSHIPS IN FAMILY LIFE AND SEX EDUCATION (6)—Open to master's degree students majoring in child development and family relationships and preparing for teaching family life and sex education in elementary or secondary schools; stipend $2,000-$2,200 plus dependency allowance.

U. S. OFFICE OF EDUCATION, BUREAU OF RESEARCH, RESEARCH TRAINEESHIPS IN PHYSICAL EDUCATION AND RECREATION (8)—Open to graduate students pursuing the doctoral degree in preparation for careers in research; stipend $2,400-$2,800 per year plus dependency allowance.

U. S. OFFICE OF EDUCATION TRAINEESHIPS IN EDUCATIONAL PSYCHOLOGY (6)—Open to graduate students majoring in educational psychology and preparing for careers as educational research workers; stipend $2,400-$2,800 plus dependency allowance.

U. S. PUBLIC HEALTH SERVICE AIR POLLUTION SPECIAL FELLOWSHIP (POST-DOCTORAL)—Available to post-doctoral scholars in the physical sciences, biological sciences, and social sciences; stipend $6,000-$7,000 plus dependency allowance.

U. S. PUBLIC HEALTH SERVICE TRAINEESHIPS IN AIR POLLUTION (26)—Open to selected graduate students in the physical sciences, biological sciences, and social sciences; stipend $3,000-$3,600 plus dependency allowance. Applications and information available through the Center for Air Environment Studies.

U. S. Public Health Service Traineeships in Clinical Psychology (18)—Open to selected graduate students in this area of psychology; stipend $1,800-$3,000.

U. S. Public Health Service Traineeships in Microbiology (4)—Open to selected graduate students in microbiology; stipend $2,400-$2,800.

U. S. Public Health Service Traineeships in Public Health Nutrition (5)—Open to selected graduate students in foods and nutrition; stipend $3,000.

U. S. Public Health Service Traineeships in Social Gerontology (12)—Open to selected post-master's graduate students in the social and behavioral sciences; stipend $2,600-$2,800 plus dependency allowance. Apply to director, Program in Adult Development and Aging.

U. S. Rehabilitation Services Administration Traineeships in Speech Pathology and Audiology (11)—Open to graduate students specializing in speech pathology and audiology; stipend $2,400-$3,400.

United States Steel Fellowship—Available to a graduate student in metallurgy; stipend $2,385 per year (three terms).

U. S. Vocational Rehabilitation Administration Traineeships in Vocational Rehabilitation Counseling (36)—Open to graduate students in counselor education who are specializing in vocational rehabilitation counseling; stipend $1,800-$2,000.

Veterans Administration Internships in Clinical Psychology (5)—Open to selected advanced graduate students in this area of psychology; stipend $3,500-$6,500, not including tuition and fees.

Walter Thomas Memorial Scholarship—Available to a student studying the nutrition of horticultural crops; stipend variable.

In addition grants are available from governmental agencies, industrial concerns, foundations, and the armed forces for graduate study and frequently for support of investigations of particular problems. Some of these permit full-time study and carry the same exemptions as the fellowships listed above. Detailed information may be secured from departments.

EXTERNALLY SPONSORED FELLOWSHIP AND TRAINEESHIP PROGRAMS—Attention is directed to the following national programs, involving numerous fields of study, with which the University cooperates by providing local administration. (See statement on nondiscrimination, p. 58.)

Atomic Energy Commission Special Fellowships in Nuclear Science and Engineering—These fellowships are available to United States citizens who hold bachelor's degrees in engineering or physical science (chemistry, earth science, mathematics, or physics) and who have completed mathematics through ordinary differential equations. Applicants for first-year fellowships will be required to take the Graduate Record Examinations, designed to test aptitude and achievement, which are administered in January at a large number of centers in the United States and overseas. Before a fellowship appointment becomes effective, the fellow must be granted fellowship clearance by the Atomic Energy Commission and must be accepted by a participating university for study leading to an advanced degree. The deadline for filing applications for fellowships beginning in September is the first of the preceding January. Forms may be obtained from the NSE Fellowship Office, Oak Ridge Associated Universities, Oak Ridge, Tennessee. About 200 will be awarded.

Housing and Urban Development Graduate Fellowships—For the graduate training of professional city planning and urban and housing technicians and specialists; carry stipends of $3,000 per year plus tuition plus $500 per dependent. About 100 are awarded annually in national competitions. Application forms are available from Urban Studies Fellowship Program, Community Development Training Divisions, U. S. Department of Housing and Urban Development, Washington, D. C., 20410, and must be completed and filed by April 15 for study starting the following September.

International University Fellowships in Space Science—These graduate and post-doctoral fellowships are available to foreign nationals who hold the equivalent of master of science or master of engineering degrees and meet graduate student en-

trance requirements at United States universities. Details on the program will be found in the brochure concerning these fellowships issued by the Office of Scientific Personnel, National Academy of Sciences, Washington, D. C.

National Aeronautics and Space Administration Traineeships (7)—Open to outstanding graduate students in natural science and engineering preparing for careers in research; stipend $2,400-$3,400 per year plus tuition. Apply to head of department of major.

National Defense Graduate Fellowships—Under Title IV of the National Defense Education Act of 1958, as amended, the U. S. Commissioner of Education makes an allotment of three-year fellowships to approved institutions which have applied for them and designates the major fields among which the awards may be distributed. One purpose of these awards is to assist able graduate students who certify their interest in college or university teaching to obtain their doctorates, thus increasing the higher education teaching staff nationally. The program also aims to increase the development and utilization of doctoral degree training facilities and promote their wider distribution geographically.

Two-thirds of these fellowships in an institution must be awarded to students with no more than one-half year of graduate study by September; the remainder may be awarded to those who have completed no more than two years of graduate study by September. These awards compare favorably with the best fellowships available. The University had 182 students studying under these fellowships in forty-two different fields of the arts and sciences in 1969-70.

No institution knows until the fall of each year whether it will have any additional fellowships under this program for the following year. A senior or an interested graduate student should inquire from the head of his actual or anticipated graduate major department. Applications will be made directly to the departments or graduate deans of institutions having programs in the desired field. Most institutions have application deadlines from February 15 to 20.

National Defense Modern Foreign Language Fellowships—Under Title VI of the National Defense Education Act of 1958, as amended, the U. S. Commissioner of Education allocates to institutions which have approved programs of study in certain languages of critical importance to the United States, and in the cultural areas related to these languages, graduate fellowships for the study of these languages and the related areas. The languages involved in this program are in general those not commonly taught in the United States. French, German, Italian, and Peninsular Spanish are excluded.

Applicants must give reasonable assurance that they will be available after graduate study for teaching a modern foreign languge or a related study in a college in the United States or for such other public service as may be specified in the application materials.

In 1969-70 the University awarded four fellowships in Russian language and area studies for majors in Slavic languages, in the Eastern European program for students majoring in Russian, and for those majoring in economics, geography, history, or political science, with emphasis on Eastern Europe but also studying a Slavic language. Write to the head of the department of one of these four departments or to the head of the Department of Slavic Languages.

National Science Foundation Graduate Fellowships—The Graduate School cooperates in this program of prestige fellowships requiring outstanding credentials and available in the biological, engineering, mathematical, and physical sciences; anthropology; economics (excluding business administration); geography, history and philosophy of science; political science; psychology (excluding clinical); and sociology (excluding social work). Also included are interdisciplinary fields such as biophysics, geochemistry, meteorology, and physiology. These fellowships are used at the university of one's choice. Application is made during the fall to the Fellowship Office, National Academy of Sciences-National Research Council, 2101 Constitution Ave., N.W., Washington, D. C. 20418, which has charge of evaluating applicants for

the Foundation. About 1,929 new awards were made for 1969-70. The application deadline for 1970-71 was December 5, 1969.

National Science Foundation Graduate Traineeships—This program was expanded in 1966-67 to include all the areas supported by the Graduate Fellowship Program mentioned above. The National Science Foundation awards training grants to various recognized universities to accelerate the output of graduate students in these fields and to help meet the nation's future needs for scientific and professional manpower. These grants permit a university to award a specified number of traineeships, 80 per cent of which must go to first-year graduate students. These awards compare favorably with the best fellowships. In 1969-70 the University had eighty-three of these traineeships distributed through thirty-four areas supported by NSF. Stipends are the same as for National Science Foundation Fellowships. An applicant should write to the head of the department in his graduate field.

National Science Foundation Science Faculty Fellowships—These awards are made to enhance the effectiveness of college faculty members who have at least three years' experience as full-time staff members teaching science, mathematics, or engineering mainly to undergraduates. They are awarded to those working for a Ph.D. or to those holding the degree and teaching in any of the fields supported by the NSF Graduate Fellowship Program. Tenure may be from three to fifteen months and can be spread over three successive summers. For information, write to the National Science Foundation, Washington, D. C. 20550. The application deadline for 1970-71 was October 6, 1969; about 212 awards were made.

U. S. Public Health Service Predoctoral Fellowships—Available to graduate students in anatomy, anthropology, behavioral sciences, biochemistry, biomedical engineering, biophysical sciences, biostatistics, botany, developmental biology, endocrinology, entomology, genetics, history of life sciences, medicinal chemistry, microbiology, nursing, nutrition, organic chemistry, pathology, pharmacology, physiology, social and psychological sciences, zoology, and air and water pollution. These fellowships are used at the university of one's choice and are more frequently awarded to second- or third-year graduate students. Prior to formal application a senior must have been admitted to a graduate school and have obtained a sponsor there who will supervise his training. Application should be made to the Career Development Review Branch, Division of Research Grants, National Institutes of Health, Bethesda, Maryland 20014, by October 1 for awards announced in February, by January 2 for June awards, and by April 1 for September awards. Approximately 2,000 are awarded annually.

Woodrow Wilson National Fellowship—Awarded by the Woodrow Wilson National Fellowship Foundation for first-year graduate study at the institution of one's choice to outstanding students who show a clear preference for a career in college teaching, especially in the areas of the humanities and social sciences. Science and mathematics majors will be considered; but they must also apply for National Science Foundation Fellowships, and, if one is received, the applicant must accept it in preference to the Woodrow Wilson award. Each student must be nominated by a professor in his undergraduate college. The nomination is sent to the regional representative of the Woodrow Wilson Fellowships for the area in which that college is located. An interested student should consult the dean or other official of his college, or write to the Woodrow Wilson National Fellowship Foundation, Box 642, Princeton, N. J. Nominations must reach the regional chairman by October 31 each year.

One hundred awards were made for 1969-70, selected from a Designate List of the top thousand applicants. The list of Designates will be sent to ten leading graduate schools to which the Ford Foundation is distributing over 41 million dollars for the next seven years to enable these institutions to support a certain number of graduate students throughout their complete doctoral programs, not just for one year. This prestige list of applicants will also be sent to all graduate schools which offer

the Ph.D. in the humanities and social sciences. Those not accepted by the above schools will constitute a list of outstanding applicants for other graduate schools to consider.

OTHER AIDS

RESIDENT ASSISTANTSHIPS FOR MEN—A number of appointments are available to male graduate students to serve as resident assistants in the undergraduate men's residence halls. A resident assistant's responsibility is to work for the social, academic, and emotional adjustment of the undergraduate residents. Specialized training and experience in personnel work are helpful, although not essential. These appointments are for three terms (fall, winter, and spring). Remuneration is in the form of room, board, and full in-state tuition. A resident assistant may not hold a fellowship or an additional assistantship during the term of his appointment, nor may he engage in any other form of part-time employment. He may carry 7 to 9 credits per term. Requests for further information and application materials should be addressed to the Division of Residence Hall Programs, 117 Old Main, University Park, Pa. 16802.

SENIOR RESIDENT POSITIONS FOR WOMEN—Full-time salaried appointments as senior residents in undergraduate halls for women are available to qualified women graduate students. Responsibilities include working with student groups in a programming capacity, counseling, and supervising the residence hall during the evening. Preference is given to persons working for master's degrees in higher education, specializing in student personnel administration.

These positions permit the holders to take 4 graduate credits per term at reduced tuition. Appointments are made for the fall, winter, and spring terms. Special arrangements of hours of work and credits may be made for the summer term. It is thus possible to complete work for a master's degree in two calendar years.

Requests for information and application materials should be addressed to the Division of Residence Hall Programs, 117 Old Main, University Park, Pa. 16802.

GRADUATE GRANTS-IN-AID—Forty grants for full-time study are awarded each year on a term basis, providing for all tuition. They are available to any student on the basis of financial need and academic promise. A recipient is expected to carry a full program of graduate work but may accept employment with the University or another employer not to exceed ten hours per week, provided he reduces his academic load to 8 or 9 credits. Application for renewal of the grant-in-aid may be made for succeeding terms. The value of these grants to Pennsylvanians is $200 per term, to non-Pennsylvanians, $450 per term. A few grants are available for students beginning graduate study in the winter or spring term, if applications are filed six weeks before registration for that term.

Applications should be addressed to the Dean of the Graduate School and must be received by March 15 to be considered for the following summer or fall.

DU PONT TEACHING AWARD IN CHEMISTRY—To be eligible for the E. I. du Pont de Nemours and Company Postgraduate Teaching Assistant Award, a graduate student must be currently serving as a part-time teaching assistant and preferably should have had two years of experience in this capacity. The recipient receives $1,200 in addition to the regular stipend paid him as a teaching assistant.

THE RUTH YOUNG BOUCKE GRADUATE FELLOWSHIP—Established from the

estate of Ruth Young Boucke, whose husband was for many years a professor of economics, this fellowship is available every other year to an outstanding graduate student on the same basis as the regular Graduate School fellowships, and selection is made by the Graduate School Committee on Fellowships and Awards. The stipend is $1,800 for a tenure of three terms plus a grant-in-aid for tuition.

JOHN W. WHITE FELLOWSHIPS—Awarded to two or three graduates of The Pennsylvania State University each year on the basis of scholarship, need, character, and aptitude. The recipients may enroll in any approved college or university. Application is made to the Office of Student Aid, 121 Grange Building.

SCHOLARSHIPS—A number of scholarships furnished by outside agencies and organizations are awarded annually through individual departments. A request for information should be directed to the department head in the field of the student's major interest.

A.A.U.W. SCHOLARSHIP—The State College Chapter of the American Association of University Women has established a modest scholarship which is awarded annually to honor an outstanding woman graduate student. The award does not include exemption from tuition. Nominations are made by departments.

LOANS ADMINISTERED BY THE UNIVERSITY—The Director of the Office of Student Aid has charge of all loans administered by the University, for both undergraduate and graduate students. Application forms may be obtained from his office in 121 Grange Building. Funds are available from three sources:

University Loan Funds have been established through the generosity of University organizations, alumni, faculty, staff, and friends. Graduate students without assistantships who are registered for full credit loads may obtain long-term loans, while graduate assistants who are classified as full-time students by the Dean of the Graduate School may qualify only for short-term loans from these funds. Applicants must demonstrate a need for financial assistance in meeting University-related expenses and be United States citizens, except that international students may qualify for short-term loans if they can secure a responsible resident of Pennsylvania as cosigner of the note. The interest on long-term loans does not begin until after graduation and generally is at a low rate for the first two years.

National Defense Education Act Loan Funds are available for United States citizens from the federal government, this act having been expanded in the fall of 1964 to increase the amount allotted to each institution and to increase the ceiling on loans to graduate students to $2,500 per year. The forgiveness of half the loan over a five-year period for those entering teaching has been extended to college teaching and to teaching in private elementary and secondary schools, as well as to teaching in public elementary and secondary schools. Interest at 3 per cent does not start until nine months after the borrower ceases to be a full-time student. Repayment must then be made at the rate of no less than $15 per month.

The Alumni Graduate Student Loan Fund has been established through the efforts of the University Alumni Fund and contributions of Graduate School alumni who have received their bachelor's degrees elsewhere. The Graduate Student Association has also made sizable contributions to it. The purpose of this fund is to assist graduate students on a short-term loan basis in meeting somewhat unexpected financial obligations associated with receiving a degree, such as thesis typing, thesis binding and microfilming fee, job interview travel, etc. Students who have completed all required credits and are not registered, but are completing their theses and anticipating graduation at the next commencement, may qualify for these loans.

OTHER AIDS

STATE HIGHER EDUCATION LOAN PLANS—A number of states have passed laws which enable them to set up agencies to guarantee loan agreements with commercial banks, enabling cooperating banks in those states to make long-term personal loans to qualifying students to help pay their college or graduate school expenses. This cooperation makes possible lower interest charges and longer repayment periods than are available for ordinary personal loans.

Pennsylvania has established the Pennsylvania Higher Education Assistance Agency for those who have been residents of Pennsylvania for one year prior to filing applications and are accepted for enrollment in approved institutions of higher education. A full-time graduate student may borrow up to $1,000 per year, the total not to exceed $7,500 during the entire period of his post-secondary education. To be eligible, a part-time graduate student must be enrolled for at least 6 credits and is limited to $500 per year. The federal government will generally pay the interest on behalf of the student while he/she is enrolled in school and the first 3 per cent of interest while the student is making repayment following graduation or withdrawal from school. Repayment of the principal of the loan is not required until the student leaves or graduates from school. Generally, to be eligible for the interest subsidy, the annual adjusted family income must be below $15,000 per year and the student must be enrolled in an eligible course of study in a nonprofit institution. A list of participating lending institutions is available from all secondary school counselors, school financial aid officers, or the Pennsylvania Higher Education Assistance Agency, Guarantee Loan Program, Towne House, Harrisburg, Pennsylvania 17102.

Residents of other states should inquire of their state education departments regarding the existence of similar plans. Practically all the states of the United States, and the District of Columbia, have such programs.

ASSURED EDUCATION PLAN—The University offers to sponsors (including parents) of students the Assured Education Plan, enabling them to pay out of current income, on a monthly basis, University bills for tuition, residence hall room and board, and all other items billed by the University. Life insurance and total and permanent disability insurance are a part of the plan for the sponsor up to his sixty-eighth and sixty-first birthdays, respectively. Payments are handled through the Girard Trust Bank, Philadelphia, Pa. Further information and application forms may be obtained from the Office of the University Bursar, 103 Shields Building. Signed agreements should be received well in advance of registration, since it takes at least three weeks for completion of arrangements.

STUDENT EMPLOYMENT—Many students depend upon part-time employment to help meet their expenses. A student who is thus employed, however, must recognize the time demands of his work schedule and will be required to adjust his academic load accordingly.

A student who holds a graduate assistantship, fellowship, or traineeship may not accept employment, either at the University or elsewhere, during the period of his appointment, except when stipulated for training purposes in certain foundation and federal fellowship and traineeship programs.

The Office of Student Aid, 121 Grange Building, offers assistance to students in finding part-time employment in town as well as on the campus.

VETERANS' BENEFITS—The Coordinator of Veterans Affairs has the responsibility of handling all applications for benefits under the various Public Laws.

Under P. L. 89-358, a student is classified as full-time if he registers for 8 or more credits, or if he holds a half-time or quarter-time graduate assistantship.

After each term's registration, the number of credits scheduled must be reported to the University Coordinator of Veterans Affairs for enrollment certification to the Veterans Administration.

Recently discharged servicemen not in this area may obtain information on veterans' educational benefits under P. L. 89-358 and its recent revision from the Veterans Administration representatives at their local county courthouses.

PROGRAMS AND COURSES

Programs of study leading to advanced degrees are offered in many major and minor fields. These are listed in the following section, and the major fields are summarized at the beginning of the following section. Related courses are grouped together under the name of the field. To locate a particular course or group of courses, consult the index.

In general, departments of the University are identified with specific major fields. Thus aerospace engineering is a major field of study which is offered under the supervision of the Department of Aerospace Engineering. On the other hand, engineering acoustics and comparative literature are major fields for which there are no corresponding departments. In such cases a committee of the Graduate School is responsible for administering the program. In some cases a single department offers work in more than one field. Thus the Department of Materials Science offers work in ceramic science, fuel science, metallurgy, and solid state science.

Applicants for admission are encouraged to consult the person whose name is listed under the major field heading.

DEGREES—In those major fields approved for the doctorate, the Ph.D. is normally conferred, although a program leading to the D.Ed. may also be arranged with the consent of the department or committee in charge if such a professional program is appropriate. Similarly, in major fields approved for the master's degree the M.A. or M.S. is normally conferred, but a program leading to the M.Adm., M.Agr., M.B.A., M.Ed., M.Eng., M.F., M.F.A., M.P.A., or M.R.P. may also be available. The D.Ed. and M.Ed. are not limited to the fields of education but, with the consent of the department or committee in charge, may be offered in any approved major field appropriate to the preparation of teachers, such as mathematics or English. In this case the program is sponsored by a major department outside the fields of education, such as the Department of Mathematics, but the student's minor is in education.

MINOR FIELDS—All major fields listed are also acceptable as minors, subject to the approval of the proposed minor department. In addition, a few fields in which no advanced degrees are offered have been approved as minors for candidates who are majoring in related areas. Such minor fields are identified in the summary at the beginning of the following section and by a brief statement under the field heading in that section.

A candidate's choice of minor field depends upon the particular degree he is seeking and is subject to the approval of both his major and minor departments. The requirements in each minor field are established by the minor department subject to the regulations of the Graduate Faculty.

INTERDISCIPLINARY MAJORS—In addition to the majors listed on the following pages, interdisciplinary majors involving two or more departments may be arranged with the approval of the Dean of the Graduate School. These programs are offered under the supervision of appropriate interdepartmental committees.

OTHER FIELDS—Fields which have not been approved for either major or minor work, but in which approved courses are offered, are listed at the end of this bulletin. These courses may be used in graduate programs as electives or as part of a general studies program, subject to the approval of the major department and to the restrictions upon the use of 400-series courses in degree programs.

COURSE NUMBERING SYSTEM—Courses in the series 1-399 are not listed in this bulletin because they are strictly undergraduate and yield no graduate credit. A graduate student may register for or audit these courses in order to make up deficiencies or fill in gaps in his earlier education but not to meet requirements for an advanced degree.

Courses in the series 400-499 are for upperclassmen with at least junior standing

and for graduate students. Only a limited number of credits earned in these courses may be counted toward the requirements for an advanced degree. Detailed regulations concerning the restrictions are given on pages 46-52 under the specific requirements for the various master's degrees.

Courses in the series 500-599 are restricted to students registered in the Graduate School, seniors with an average of at least 3.50, and other students who have been granted permission to enroll by the Dean of the Graduate School.

The numbers 601 and 611 do not denote courses but are used for noncredit registration by a Ph.D. candidate who is following the new regulations which went into effect in fall term 1967. Registration under these numbers will maintain his status as a student during the interval which begins at the time he has both passed the comprehensive examination and met the three-term, full-time academic requirement and ends at the time his doctoral committee accepts the thesis. The student will register for 601 if he will be using University facilities and/or faculty services; he will register for 611 if he will be off-campus and requiring little or no faculty service.

CREDITS—A credit is defined as a unit of time approximately equivalent to one week of full-time graduate study. Accordingly, a full-time student having no concurrent employment may earn a maximum of 10 credits in a ten-week term. A "credit" as used in this bulletin, therefore, is identical in meaning with a "semester credit" and should not be confused with a "quarter credit," which is associated with the traditional quarter system. By increasing the length of class periods to seventy-five minutes, the Penn State calendar based upon a ten-week term provides for the same amount of time in a given course as does the typical semester plan.

COURSE DESCRIPTIONS—A course abbreviation, a number, and a title designate each course. Course designations and official abbreviations are listed in the left-hand margin just above the first course in each group. The figures in parentheses following the course title show the number of credits which may be granted for that course. In the case of courses with variable credits, the number of credits which may be earned in a single term is determined by the department offering the course.

A department may schedule an entire section of a course below the 400 level for fewer credits than the maximum authorized. In 400- and 500-series courses a department may schedule an individual student for fewer credits than the maximum number but in no case for more than the maximum number authorized.

SCHEDULE OF COURSES—A complete list of the courses which will be offered in any specific term is given in the *Schedule of Classes,* which is available at nominal cost from the Scheduling Office approximately four months before the beginning of the term. It gives the number of credits being offered in each course, the hours at which the class will meet, the location of the class, and in some cases the instructor's name.

RESEARCH AND THESIS WORK—In registering for thesis work a student uses the appropriate number (600, 601, 610, or 611) preceded by the abbreviation designating his major field. Thus, ENGL 600 denotes thesis research in English being done on the University Park Campus and ENGL 610 thesis research in English being done off-campus.

The numbers 601 and 611 are available only to Ph.D. candidates who are following the new regulations, have passed the comprehensive examination, and have met the three-term, full-time academic requirement. Such a candidate in engineering mechanics will register for E MCH 601 if he will be using University facilities and/or faculty services or for E MCH 611 if he will be off-campus and requiring little or no faculty service.

It should be assumed that 600 and 610 are available in all graduate major fields and that 601 and 611 are available in all fields approved for the Ph.D., although these numbers may not always appear in the *Schedule of Classes* for each term.

Major and Minor Fields

GRADUATE FIELDS OF STUDY

Administration—M.Adm.
Aerospace Engineering—Ph.D., M.S.
Agricultural Economics—Ph.D., M.S., M.Agr.
Agricultural Education—Ph.D., D.Ed., M.S., M.Ed.
Agricultural Engineering—Ph.D., M.S.
Agronomy—Ph.D., M.S., M.Agr.
Anatomy—Ph.D., M.S.
Animal Industry—Ph.D., M.S., M.Agr.
Animal Nutrition—Ph.D., M.S.
Anthropology—Ph.D., M.A.
Architectural Engineering—M.S.
Architecture—M.S.
Art—M.A., M.F.A.
Art Education—Ph.D., D.Ed., M.S., M.Ed.
Art History—Ph.D., M.A.
Astronomy—Ph.D., M.S.
Biochemistry—Ph.D., M.S.
Biological Chemistry—Ph.D., M.S.
Biological Science—D.Ed., M.Ed.
Biology—Ph.D., M.S.
Biophysics—Ph.D., M.S.
Botany—Ph.D., M.S.
Business Administration—Ph.D., M.S., M.B.A.
Business Education—Ph.D., D.Ed., M.S., M.Ed.
Ceramic Science—Ph.D., M.S.
Chemical Engineering—Ph.D., M.S.
Chemistry—Ph.D., M.S.
Child Development and Family Relationships—Ph.D., D.Ed., M.S., M.Ed.
Civil Engineering—Ph.D., M.S., M.Eng.
Classics—M.A.
*Clothing and Textiles
Comparative Literature—Ph.D., M.A.
Computer Science—Ph.D., M.S.
Counselor Education—Ph.D., D.Ed., M.S., M.Ed.
Dairy Science—Ph.D., M.S.
Earth Sciences—M.Ed.
Economics—Ph.D., M.A.
Education of Exceptional Children—Ph.D., D.Ed., M.S., M.Ed.
Educational Administration—Ph.D., D.Ed., M.S., M.Ed.
Educational Psychology—Ph.D., M.S.
Electrical Engineering—Ph.D., M.S.
Elementary Education—Ph.D., D.Ed., M.S., M.Ed.
Engineering Acoustics—Ph.D., M.S., M.Eng.
Engineering Mechanics—Ph.D., M.S., M.Eng.
Engineering Science—M.Eng.
English—Ph.D., D.Ed., M.A., M.Ed.
Entomology—Ph.D., M.S., M.Agr.
Extension Education—M.Agr., M.Ed.
Family Economics and Home Management—Ph.D., D.Ed., M.S., M.Ed.
Food Science—Ph.D., M.S.
*Food Service and Housing Administration
Foods and Nutrition—Ph.D., D.Ed., M.S., M.Ed.
Forest Resources—Ph.D., M.S., M.F.
French—Ph.D., M.A.
Fuel Science—Ph.D., M.S.
General Engineering—M.Ed., M.Eng.
General Family Studies—M.S., M.Ed.
Genetics—Ph.D., M.S.
Geochemistry—Ph.D., M.S.
Geography—Ph.D., D.Ed., M.S., M.Ed.
Geology—Ph.D., M.S.
Geophysics—Ph.D., M.S.
German—Ph.D., M.A., M.Ed.
Higher Education—D.Ed., M.Ed.
History—Ph.D., D.Ed., M.A., M.Ed.
Home Economics Education—Ph.D., D.Ed., M.S., M.Ed.
Horticulture—Ph.D., M.S., M.Agr.
Industrial Arts Education—Ph.D., D.Ed., M.S., M.Ed.
Industrial Engineering—Ph.D., M.S., M.Eng.
Journalism—M.A.
Laboratory Animal Medicine—M.S.
Man-Environment Relations—Ph.D., D.Ed., M.S., M.Ed.
Mathematics—Ph.D., D.Ed., M.A., M.Ed.
Mechanical Engineering—Ph.D., M.S., M.Eng.
Medical Technology—M.S.
Metallurgy—Ph.D., M.S.
Meteorology—Ph.D., M.S.
Microbiology—Ph.D., M.S.
Mineral Economics—Ph.D., M.S.
Mineral Engineering Management—M.Eng.
Mineral Preparation—Ph.D., M.S.
Mineralogy and Petrology—Ph.D., M.S.
Mining Engineering—Ph.D., M.S.
Music—M.A., M.F.A.
Music Education—D.Ed., M.Ed.
Nuclear Engineering—Ph.D., M.S., M.Eng.
Nutrition in Public Health—M.S.
Petroleum and Natural Gas Engineering—Ph.D., M.S.
Pharmacology—Ph.D., M.S.
Philosophy—Ph.D., D.Ed., M.A., M.Ed.
Physical Education—Ph.D., D.Ed., M.S., M.Ed.
Physical Science—D.Ed., M.Ed.
Physics—Ph.D., D.Ed., M.S., M.Ed.
Physiology—Ph.D., M.S.
Plant Pathology—Ph.D., M.S.
Political Science—Ph.D., M.A.
Poultry Science—Ph.D., M.S.
Psychology—Ph.D., D.Ed., M.S.
Public Administration—M.P.A.
Recreation and Parks—M.S., M.Ed.
Regional Planning—M.R.P.
Rural Sociology—Ph.D., M.S., M.Agr.
Sanitary Engineering—M.S., M.Eng.
School Psychology—D.Ed., M.S., M.Ed.
Secondary Education—Ph.D., D.Ed., M.S., M.Ed.
Slavic Languages and Literatures—M.A.
Social Studies—M.Ed.
Sociology—Ph.D., M.A.
Solid State Science—Ph.D., M.S.
Spanish—Ph.D., D.Ed., M.A., M.Ed.
Speech—Ph.D., D.Ed., M.A., M.Ed.
Speech Pathology and Audiology—Ph.D., D.Ed., M.S., M.Ed.
Statistics—Ph.D., M.A., M.S.
Theatre Arts—M.A., M.F.A.
Veterinary Science—Ph.D., M.S.
Vocational Industrial Education—Ph.D., D.Ed., M.S., M.Ed.
Wildlife Management—M.S.
Zoology—Ph.D., M.S.

* See Man-Environment Relations

The degrees listed above are the ones normally conferred in each of the designated major fields. Additional professional degrees, including the M.Agr., M.Ed., and M.Eng., have been authorized in many cases and may be offered at the discretion of the department head and the Dean of the Graduate School. Thus, the M.Ed. has been authorized for all of the above fields in which a master's degree is conferred provided the field is appropriate to the preparation of teachers.

COURSES IN MAJOR AND MINOR FIELDS

ADMINISTRATION (ADMIN)

ROBERT J. MCNEILL
In Charge of Graduate Programs in Administration at Capitol Campus
P. O. Box 230, Middletown, Pa. 17057

Degree Conferred: M.Adm.

This program is designed to meet the professional needs of practicing and potential administrators. A basic premise is that administration is a necessary function in all organizations and that it requires a common body of knowledge and skills regardless of its area of application. A total of 30 graduate credits is required—18 in the core courses and 12 in the area of specialization or option—with the majority of the courses at the 500 level. Four option areas are offered: business administration, engineering administration, public administration, and logistics administration. Each student is required to complete a research project in the field or in a laboratory in which he applies research methods and tests his solution through experimentation or simulation. The report must be of the quality, if not the theoretical depth, of a graduate thesis. After substantially completing the course requirements, a candidate must pass a comprehensive written and oral examination administered by a committee of graduate faculty members. The candidate will be expected to demonstrate his ability to integrate knowledge of a specialized area with a broad understanding of the general field of administration.

For admission to this program the student must have a baccalaureate degree from an accredited institution including preparation at the level of differential and integral calculus in mathematics, inference in statistics, and micro- and macroanalysis in economics. Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

The program is offered only at the Capitol Campus.

CORE COURSES

ADMIN. 500. ADMINISTRATIVE THEORY (3) History, significance and functions of administration, theories of leadership, authority, decision-making, rationality, and efficiency.

ADMIN. 510. ORGANIZATION ANALYSIS (3) Examination of concepts of human behavior in formal organizations, systems analysis, conceptual models, and decision processes.

ADMIN. 520. ADMINISTRATIVE MODELS (3) Formulation and solution of decision models for administrative problems. Analysis of decision-making under certainty, risk, and uncertainty.

ADMIN. 530. RESEARCH ON ADMINISTRATIVE PROBLEMS (6) Studies in research design, analysis, and interpretation. Student independently conceptualizes, designs, and executes a comprehensive research project.

ADMIN. 540. ADMINISTRATIVE POLICY FORMULATION (3) Analysis of administrative problems from a total organization viewpoint. Case studies of actual organizations are used for analysis.

BUSINESS ADMINISTRATION OPTION*

ACCTG. 511. INTERPRETATION OF ACCOUNT DATA (3)

FIN. 531. FINANCIAL MANAGEMENT (3)

MGMT. 510. OPERATIONS MANAGEMENT (3)

MKTG. 500. MARKETING MANAGEMENT (3)

ENGINEERING ADMINISTRATION OPTION*

I.E. 425. INTRODUCTION TO OPERATIONS RESEARCH (3)

I.E. 502. MANAGEMENT METHODS (3-6)

I.E. 508. METHODS OF OPERATIONS RESEARCH (3)

I.E. 509. METHODS OF OPERATIONS RESEARCH (3)

I.E. 510. METHODS OF OPERATIONS RESEARCH (3)

I.E. 513. DATA PROCESSING AND PROGRAMMING (3)

PUBLIC ADMINISTRATION OPTION*

PL.SC. 575. GOVERNMENT MANPOWER MANAGEMENT (3)

PL.SC. 576. GOVERNMENT FISCAL DECISION-MAKING (3)

ADMIN. 550. PROGRAM PLANNING AND EVALUATION (3) Analysis and evaluation of public programs and systems from the perspectives of policy development and administrative planning and management.

ADMIN. 551. ADMINISTRATION AND THE POLITICAL PROCESS (3) Analysis of the relationship of administration to the political processes that shape public policy formulation and execution.

LOGISTICS ADMINISTRATION OPTION*

B.LOG. 504. PROBLEMS IN BUSINESS LOGISTICS (3)

B.LOG. 538. TRANSPORTATION AND PHYSICAL DISTRIBUTION (3)

B.LOG. 565. SEMINAR IN BUSINESS LOGISTICS (3-6)

AEROSPACE ENGINEERING (AERSP)

BARNES W. MCCORMICK, *Head of the Department*
233 Hammond Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Holl, Lancaster, Lumley, McCormick, and Sevik; Associate Professor Tennekes.
Graduate Faculty, Associate Members: Assistant Professors Arndt, Kaplan, Lakshminarayana, Phillips, and York.

* Courses listed under this option are described under the designated field of study.

Opportunities are available for graduate study in the following and related areas: modern fluid mechanics and physics, the interaction of fluids with solids, and the application of these disciplines to the design of devices and to the environment in which they operate. These topics are specifically included: cavitation, rarefied gas-dynamics and plasma physics, stability of laminar motions, turbulence, geophysical fluid mechanics, aeroelasticity and hydroelasticity, stability and control of vehicles, turbomachinery and propulsion, V/STOL aircraft, high lift devices, ground effect machines, astrodynamics, and aerospace systems.

The entering student must hold a bachelor's degree in physical science, mathematics, or engineering and may be required to complete (without degree credit) undergraduate course work in fluid and solid mechanics and intermediate mathematical analysis, if he has not already done so. Students having a junior-senior average of 2.70 or above will be considered, within the limitations of departmental facilities. Exceptions to these requirements may be made for students with special backgrounds, abilities, and interests.

AEROSPACE ENGINEERING (AERSP)

401a,b,c. Aerospace Engineering Projects (1-12)
402. Aerospace Design (2)
405. Experimental Methods in Aerospace Engineering (3)
407. Aerodynamics of V/STOL Aircraft (3)
410. Aerospace Propulsion (3)
411. Aeroelasticity (3)
412. Turbulent Flow (3)
413. Stability and Control of Aircraft and Missiles (3)
415. Physical Gas Dynamics (3-6)
416-417. Aerospace Undergraduate Thesis (2 each)
420. Principles of Flight Testing (3)
421. (M.E. 421) Intermediate Viscous Flow (3)
422. (M.E. 422) Intermediate Inviscid Flow (3)
425. Theory of Flight (3)
430. Space Propulsion and Power Systems (3)
450. Orbit and Attitude Control of Spacecraft (3)

503. Electromagnetically and Chemically Active Flows (3) Flow of media which may be conductive, permeable, ionizable, or otherwise capable of interacting with imposed or self-generated fields.

504. Aerodynamics of V/STOL Aircraft (3) Jet wings, high lift devices, propellers and ducted propellers, circulation and boundary layer control, unsteady airfoil theory. Prerequisite: Aersp. 407.

505. Aero- and Hydroelasticity (3) Interaction of elastic systems having several degrees of freedom with fluid flows in various configurations.

506. Cavitation (3) Flow regimes, dynamics of cavitation, prediction of the minimum pressure in the fluid, scale effects, effect of surface irregularities.

507. Theory and Design of Turbomachinery (3) Theory and principles of machinery design: compressors, turbines, pumps, and rotating propulsors; opportunity to work out design examples.

508. Perfect Fluid Theory A (3) Mathematical review, equations of motion and general consequences, application of complex variables to two-dimensional flow, conformal representations, Stokes' stream function.

509. Perfect Fluid Theory B (3) Review of axisymmetric motion; two-dimen-

sional vortex motions; motions with cylindrical, spherical geometry; Bessel, Legendre functions; vortex motions in space. Prerequisite: Aersp. 508.

510. Compressible Flow (3) One-dimensional motion, shock waves, flow in nozzles, two-dimensional flow, airfoil theory. Prandtl-Meyer flow, method of characteristics.

512. Viscous Flow (3) Stress-deformation relations; Newtonian fluids, Navier-Stokes equations; exact, asymptotic laminar solutions; instability, transition; similitude and turbulent boundary layer.

514. Stability of Laminar Flows (3) The stability of laminar motions in various geometries as influenced by boundary conditions and body forces of various kinds.

515. Foundations of Turbulence (3) The mathematics underlying turbulence theory: descriptions, kinematics of stochastic fields; techniques of solution of linear and some nonlinear problems.

516. Homogeneous Turbulence (3) Dynamics: production, spectral transfer, dissipation, decay of energy; similarity theories.

517. Inhomogeneous Turbulence (3) Dynamics: similarity, structural hypotheses; spatial, spectral budget of energy in a number of classical flows.

518. Aircraft and Missile Dynamics (3) Dynamical problems of aircraft and missiles including launch, trajectory, optimization, orbiting, re-entry, stability and control, and automatic control. Prerequisite: Aersp. 413.

520. Selected Topics in Aerospace Engineering (1-12)

AGRICULTURAL ECONOMICS (AG EC)

Lee M. Day
Head of the Department of Agricultural Economics and Rural Sociology
6-A Weaver Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty, Senior Members: Professors Bait, Becker, Bennett, Brandow, Butz, Day, Frey, Hutton, McAlexander, Pasto, Pierce, Stemberger, and Trotter; Associate Professor Partenheimer.
Graduate Faculty, Associate Members: Associate Professors Herrmann and Madden; Assistant Professors Gamble, Hallberg, Holt, Jansma, and Schutjer.

The graduate program emphasizes economic theory and analytical techniques in the fields of farm management, production economics, agricultural marketing, resource economics, agricultural policy and prices, and in international agricultural trade and development.

The entering student in the master's program should have as prerequisites 3 credits in agricultural economics, 3 credits in economics, and 3 additional credits in either agricultural economics or economics. If a student lacks some of the prerequisites, he may take them without graduate credit during the early part of his master's program.

Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

AGRICULTURAL ECONOMICS (AG EC)

407. Advanced Farm Management (3)
410. Agricultural Finance and Appraisal (3)
420. Agricultural Prices (3) *Mr. Bennett*
421. Land Economics (3) *Messrs. Frey and Gamble*
422. Land and Water Resource Policy (3) *Mr. Jansma*
450. International Agricultural Trade and Development (3) *Mr. Schutjer*
460. Industrial Organization in Food Processing and Distribution (3) *Mr. Brandow*
461. Decision-Making in Agricultural Marketing Firms (3) *Mr. Stemberger*

500. Seminar in Agricultural Economics (1-6) Review of current literature and problems.

504. Seminar in Agricultural Policy (3) Analysis of farm prices, income consequences for producers and consumers, and effects on resource use; evaluation of policy, considerations in policy-making. Prerequisites: Ag.Ec. 420, Econ. 405. Odd years. *Mr. Brandow*

505. Advanced Agricultural Statistics (3) Multiple correlation, curve fitting, analysis of variance, and other techniques applicable to the rural social sciences. Prerequisite: 3 credits in statistics. *Mr. Bennett*

507. Seminar in Farm Management (1-6) Special problems relating to organization and operation of the farm business. Prerequisites: Ag.Ec. 6, Econ. 14.

514. Survey Research Techniques in Agricultural Economics (3) Survey methods and design of samples for obtaining economic data from business-unit and household populations. Prerequisite: Ag. 400. Odd years.

515. Economic Problems in the Marketing of Dairy Products (3) Economic problems as they are encountered in the process of marketing; particular attention to governmental regulation in pricing and marketing. *Mr. Pierce*

520. Farm Price Analysis (3) Econometric analysis of prices, production, and utilization of farm products; review of research in this field. Prerequisites: Ag.Ec. 420, 505; Econ. 405. Even years. *Mr. Hallberg*

524. Resource Economics (3) Economic aspects of resource use and development: economic growth, land-use planning and control, conservation, resource investment criteria and policies. Prerequisite: Ag.Ec. 421 or 422.

525. Research Methods in Rural Social Sciences (2) Scientific method in planning and conducting research. Prerequisite: 9 credits in social sciences. *Mr. John*

527. Seminar in Applied Quantitative Methods (1-4)

534. Agricultural Production Economics (3) Economic theory applied to agricultural production problems: resource combinations, firm size, uncertainty and expectations, aggregate aspects of production, technological change.

535. Seminar in Agricultural Marketing (2)

550. Food Consumption Economics (3) Demand theory and research methods applied to the market for foods. *Mr. Herrmann*

571. Seminar in Land and Water Resource Economics (3) Critical review of research in resource economics; consideration of special topics in resource use. *Mr. Jansma*

AGRICULTURAL EDUCATION (AG ED)

DAVID R. MCCLAY, *Head of the Department*
101 Agricultural Education Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors McClay and Stevens, Associate Professor Stinson.
Graduate Faculty, Associate Members: Associate Professors Anthony and Hoover, Assistant Professor Curtis.

Graduate programs emphasize the professional improvement of teachers. They provide advanced preparation for employment in administration, supervision, teacher education, and research in agricultural education and related fields. A minor may be taken in an area of agricultural science, technology, business, or in general studies. Programs may include courses needed for certification in other fields of education.

Prerequisite to admission is a minimum of 18 credits in professional education courses or certification as a teacher of agriculture. Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

AGRICULTURAL EDUCATION (AG ED)

400v. EDUCATIONAL PROGRAMS IN AGRICULTURE FOR DEVELOPING COUNTRIES (3)
418v. SURVEY OF VOCATIONAL EDUCATION IN AGRICULTURE (1-4)
420v. INSTRUCTIONAL MEDIA IN AGRICULTURE (1-6)
422v. SUPERVISION OF VOCATIONAL EDUCATION IN AGRICULTURE (1-4)
424v. OCCUPATIONAL GUIDANCE IN AGRICULTURAL INDUSTRY (1-4)
426v. ADULT EDUCATION IN AGRICULTURE (1-4)
434v. AGRICULTURAL DEVELOPMENTS (1-6)

501v. AGRICULTURAL EDUCATION IN THE UNITED STATES (1-3) Historical development, social and philosophical foundations, and current status in relation to the total vocational-technical education program.

502v. TEACHING AGRICULTURE (1-3) Vocational education objectives, learning theory, class instruction, cooperative occupational experience, and evaluation.

503v. RESEARCH IN AGRICULTURAL EDUCATION (1-6 per term) Individual study problems in various phases of agricultural education, such as evaluation of teaching, teaching procedures, and teacher preparation.

504v. AGRICULTURAL EDUCATION SEMINAR (1 per term)

508v. ADMINISTRATION AND SUPERVISION OF AGRICULTURAL EDUCATION (1-3) Administration of state and district systems of vocational-technical education; supervision of teachers of agriculture.

509v. TEACHER EDUCATION IN AGRICULTURE (1-6) Organization and administration of university programs of teacher education in agriculture, including pre-service preparation, continuing education, research, and other services.

520v. SCIENTIFIC METHOD IN THE STUDY OF AGRICULTURAL EDUCATION (1-4) Methods of procedure in investigation and experimentation in education, accompanied by a critical examination of studies made in agricultural education.

521v. Scientific Method in the Study of Agricultural Education (1-4) Continuation of Ag.Ed. 520v; emphasis upon statistical techniques for students' individual problems.

524v. Program Development in Agricultural Education (1-3) Analysis of occupational needs of students and employment prospects; organization of courses of study and other activities of teachers.

530. Agricultural College Teaching (3) Selection and organization of subject matter for specific courses, methods of learning, teaching devices, technique of teaching, and measurements of results of teaching.

AGRICULTURAL ENGINEERING (AG E)

Frank W. Peikert, *Head of the Department*
250 Agricultural Engineering Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Mohsenin and Peikert, Associate Professor Persson.
Graduate Faculty, Associate Members: Professors Aldrich, Bartlett, Schroeder, and Stephenson; Associate Professor Kjelgaard.

Graduate programs are available in the areas of physical properties of agricultural materials; plant and animal environmental engineering; agricultural processing and food engineering; agricultural mechanization with emphasis on forage, fruits, and vegetables; rural sanitation and conservation engineering; and computer technology applied to agricultural engineering problems.

Excellent facilities, including equipment and instrumentation, are available for research in the designated areas. Among the special facilities are freeze-drying equipment for drying by sublimation, controlled environmental chambers, plant growth structures for modified atmosphere, a general purpose analog computer, and a laboratory for research on mechanical and rheological properties of agricultural materials. Laboratories are available with universal testing machines, equipped with accessories such as programmers and environmental chambers; a polariscope for photoelastic stress analysis; and acoustical and light reflectance instrumentation for research on the physical and rheological properties of agricultural materials.

Prerequisite to major work is the completion of an undergraduate major in engineering. Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

AGRICULTURAL ENGINEERING (AG E)

400. Agricultural Engineering Problems (1-7)
401. Farm Mechanics for Teachers of Vocational Agriculture (1½-9)
402. Functional Design of Agricultural Structures (3)
404. Agricultural Machinery (3)
405. Agricultural Process Engineering (3)
407. Soil Water Engineering (3)
408. Instrumentation for Agricultural Production and Processing (3)
409. Agricultural Systems Engineering (3)
410. Agricultural Power (3)

412. Physical Processes in Food Manufacturing I (3)
413. Physical Processes in Food Manufacturing II (3)
414. Physical Processes in Food Manufacturing III (3)
420. Seminar (1)
423. Physical and Rheological Measurements on Biomaterials (3)

500. Advanced Electro-Agriculture (1-6) Investigations in the application of electrical energy to processing, storing, and handling agricultural products. Seminar, written reports.

501. Advanced Farm Machinery (1-6) Application of agricultural engineering principles to design and operation of farm machinery. Prerequisite: Ag.E. 410.

502. Farm Structures Problems (1-6) Analysis of farm structures design problems.

503. Physical Properties of Plant and Animal Products (3) Physical characteristics; mechanical, rheological, thermal, electrical, and optical properties in relation to handling, storage, processing, and quality evaluation.

505. Experimental and Applied Instrumentation (4) The theory and application of electronics for instrumentation and experimental research.

507. Problems in Soil Water Engineering (1-6) Analysis of engineering problems relating to irrigation, drainage, or erosion control.

508. Advanced Problems in Farm Mechanics (1-15) Problems in farm shop practice and agricultural engineering related to the farm mechanics program of vocational education in agriculture. Prerequisites: Ag.E. 8, 14; or teaching experience in farm mechanics.

509. Research in Agricultural Engineering (1-4)

520. Agricultural Engineering Seminar (1-3) Reports on research and special topics.

AGRONOMY (AGRO)

James L. Starling, *Head of the Department*
118 Tyson Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty, Senior Members: Professors Duich, Fortmann, Hunter, Kardos, Matelski, Richer, Starling, Thomas, Washko, and Adjunct Professor Robinson; Associate Professors Baker, Cleveland, Cunningham, McKee, Adjunct Associate Professor Heald, and Adjunct Associate Professor Marshall; Assistant Professor Petersen.
Graduate Faculty, Associate Members: Associate Professors Harrington, L. J. Johnson, M. W. Johnson, Marriott, Pfeifer, and Waddington; Assistant Professors Bollag, Hall, Ranney, and Adjunct Assistant Professor Hill.

Areas of specialization include soil chemistry; soil conservation; soil classification; soil fertility; soil mineralogy; soil physics; the genetics and breeding of corn, small grains, and forage plants; forage management; turf management; potato culture; tobacco culture; weed control; and ecology of crops and pastures.

Prerequisites for major work in agronomy vary with the area of specialization, but basic courses in chemistry, mathematics, physics, and biological sciences are required.

Students who lack some of the course prerequisites may be admitted but are required to take the prerequisite courses without degree credit.

Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

AGRONOMY (AGRO)

411. Breeding of Field Crops (3) *Mr. Johnson*
415. Soil Morphology, Mapping, and Classification (3) *Mr. Petersen*
416. Soil Genesis (3) *Mr. Ranney*
417. Forest Soils (3) *Mr. Ciolkosz*
419. Soil Properties (4) *Mr. Baker*
422. Soil Conservation (3) *Mr. Cunningham*
423. Pasture and Grassland Management (3) *Mr. Washko*
424. Fertilizer Technology (3) *Mr. Marriott*
425. Principles of Field Crop Production (3) *Mr. Pfeifer*
431. Soil Fertility and Management (3) *Mr. Marriott*
438. Principles of Weed Control (3) *Mr. Hartwig*
490. Agronomic Problems (1-6) *Mr. Washko and Staff*

501. Advanced Soil Fertility (4) Interpretation of fertility experiments and diagnosis of soil-plant relationships through field appraisal, analysis, and plant symptoms. Prerequisites: Agro. 431, Biol. 441. *Mr. Hunter*

503. Agronomy Seminar (1) Weekly meeting where papers and discussions will be presented by students and staff members.

506. Soil Chemistry (4) Analyses of important chemical and biochemical reactions occurring in soils, conditions which control these reactions and their importance in soil genesis and plant growth; laboratory work in the more typical and significant analytical procedures; lectures, review of current literature, and practicum. Prerequisites: Agro. 419; Bioch. 425 or Chem. 451. *Mr. Baker*

507. Soil Physics (4) Physical properties of the soil; factors affecting them; their measurements, evaluation, and influence in determination of soil productivity. Prerequisites: Agro. 419, Bioch. 425, Phys. 215. *Mr. Kardos*

509. Genetics of Crop Plants (3) Inheritance in crop plants with particular reference to factor interaction, genetic aspects of linkage and crossing-over, quantitative inheritance, and heterosis. Prerequisite: Biol. 422. *Mr. Cleveland*

510. The Application of Cytogenetics to Plant Breeding (3) Cytogenetics, including chromosome structure and behavior, chromosome alterations, polyploidy, interspecific hybridization, and their applications to plant breeding. Prerequisite: Biol. 422. *Mr. Cleveland*

512. Field Plot Technique (4) Ramifications of analysis of variance techniques; combining and analyzing data from several experiments; selection of valid error terms. Prerequisite: Stat. 200 or Ag. 400. *Mr. Starling*

516. Humus (2) Origin and chemical nature of soil organic matter, its importance in soil processes, and its decomposition. Prerequisites: Agro. 419, 431. *Mr. Richer*

517. Farm Crops Ecology (3) Ecological factors affecting growth and development of farm crops with particular reference to effects of altered environment and management practices. Prerequisites: Agro. 28, Biol. 441. *Mr. McKee*

518. Growth and Management of Forage Crops (3) Factors affecting growth

and development of forage crops with particular reference to effects of environment, defoliation, and management practices. Prerequisites: Agro. 423, Biol. 441. *Mr. McKee*

519. The Nature of Soil Minerals (3) Modern methods for identification of the constituent minerals of soils and their relation to soil classification and agricultural practices. Prerequisites: Agro. 419, G.Sc. 23. *Mr. Johnson*

545. The Application of Statistics to Field Experiments (4) Use of advanced experimental designs in planning, analyzing, and interpreting experiments; includes lattice designs, factorials, confounding, simple and multiple covariance techniques. Prerequisite: Agro. 512. *Mr. Starling*

*550. Agronomic Problems (1-12) Provides training in selected areas of agronomy by means of supervised investigations or studies.

582. Seminar in the Breeding and Genetics of Farm Crops (1 per term)

ANATOMY (ANAT)

Bryce L. Munger, *Chairman of the Department*
The Milton S. Hershey Medical Center

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professor Munger, Associate Professors Baird and Ha, Assistant Professor B. Pubols.
Graduate Faculty, Associate Members: Assistant Professor Wolfe, Mrs. L. Pubols.

The graduate program emphasizes the general areas of gross anatomy, histology/cytology, neuroanatomy/neurophysiology, or appropriate combinations of these areas. Approaches offered include morphological (descriptive, comparative, developmental), functional (physiological, chemical), and experimental. A bachelor's degree reflecting a reasonable background in zoology or biology, mathematics, and chemistry is required; reading knowledge of one or two foreign languages is recommended. Applicants must provide complete transcripts and two letters of recommendation. Scores from the Graduate Record Examination and a personal interview are desirable.

This program is offered only at The Milton S. Hershey Medical Center.

ANIMAL INDUSTRY (A I)

Thomas B. King
Head of the Department of Animal Science
202 Armsby Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty, Senior Members: Professor Bortree, Associate Professors Gobble and Sink.
Graduate Faculty, Associate Members: Professor King; Associate Professors Sherritt, Wilson, and Ziegler.

* Credits 1-6 per term.

A student may specialize in animal production and management, animal breeding, or meats. For admission the student must complete an undergraduate major in animal science or a closely related field. Students who lack some of the course prerequisites may be admitted but are required to take the prerequisite courses without degree credit.

Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

ANIMAL INDUSTRY (A I)

400. Special Topics (1-6)
405. Meat Animal Management (4)
421. Science of Meat (3)
423. Advanced Livestock Selection (2)
424. Animal Industry Seminar (1)
431. Advanced Meat Selection and Grading (2)

500. Seminar in Animal Industry (1-6)

501. Pedigree Study (1-6) Research work in breed study history, and analytical study of breed pedigrees, and a complete survey of the herd, flock, or stud book.

502. Research in Meats (1-6 per term) Investigation of methods for handling, cutting, processing, freezing, and curing meat and meat products. Prerequisite: A.I. 421.

503. Problems in the Animal Industry (1-6) Literature review, research methods, and current research in problems relating to the animal industry.

505. Advanced Animal Breeding (1-5) Special problems in animal genetics as applied to breeding and improvement of horses, cattle, sheep, and swine. Prerequisite: An.Sc. 322.

Note: *See Animal Science under "Other Elective Graduate Courses." Also see Food Science.*

ANIMAL NUTRITION (A NTR)

B. R. Baumgardt
Chairman of the Committee on Animal Nutrition
303 Animal Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Baumgardt, Bratzler, Hartsook, and Kesler; Associate Professors Hershberger, Leach, and McCarthy.
Graduate Faculty, Associate Members: Professors Cowan and King, Associate Professor Long, Assistant Professor Scholz.

This is an interdepartmental graduate program designed to enable students to obtain thorough training in animal nutrition. The program is under the direction of a committee composed of graduate faculty members of the following departments: Animal Science, Dairy Science, Poultry Science, and Veterinary Science. Programs are offered in ruminant and nonruminant nutrition, including: physiology of nutrition;

nutritional requirements for productive functions; metabolism of carbohydrates, lipids, proteins, vitamins, and minerals; and regulation of food intake and other metabolic functions.

Undergraduate preparation should include organic and analytical chemistry, physics, biology, and mathematics. Students may be admitted with limited deficiency, but are required to make up undergraduate deficiencies without graduate credit.

Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

The following nutrition courses are offered by participating departments, and their descriptions may be found under the listings of the respective departments: D.Sc. 511, Pty.Sc. 502. Courses related to animal nutrition can be found under the following listings in this bulletin: Animal Industry, Biochemistry, Dairy Science, Foods and Nutrition, Physiology, Poultry Science, and Veterinary Science.

ANIMAL NUTRITION (A NTR)

400. Nutrition and Feed Technology (3)
401. Physiology of Nutrition (3)
402. Energy and Protein Metabolism (3)

505. Ruminology (3) Physiological, biochemical, and microbiological activities occurring within the rumen and the relation of rumen function to animal response. Prerequisites: at least one course in each of the following areas: animal nutrition, physiology, microbiology, and biochemistry.

Note: *See Animal Science listing under "Other Elective Graduate Courses."*

ANTHROPOLOGY (ANTHY)

Joseph W. Michels
Acting Head of the Department
Walnut Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty, Senior Members: Professors Baker, Carpenter, Hunt, Matson, and Sanders.
Graduate Faculty, Associate Members: Associate Professor Michels, Assistant Professors Nydegger and Escobar.

The master's program is designed to train students in general anthropology. The doctoral program is structured to train students in the following areas of specialization: new world archaeology, middle eastern archaeology, archaeological methodology, physical anthropology with special emphasis on human ecology, cultural ecology, comparative economics, personality and culture, oceanic ethnology, Latin American ethnology, sub-Saharan African ethnology, folk and peasant society.

Undergraduate preparation must include 12 credits in anthropology and archaeology or their equivalent and at least 6 credits in related sciences. A student with an excellent record but who does not meet these requirements may be admitted provided he makes up course deficiencies without graduate credit. Admission is primarily restricted to students with averages of 2.80 and with research interests directly related to the special anthropological competencies within the department. Exceptions may be made for students with special backgrounds, abilities, and interests.

A thesis is required of all M.A. candidates in this field.
The M.A. degree may be bypassed by exceptional candidates for the Ph.D. degree.

ANTHROPOLOGY (ANTHY)

400. Human Evolution: the Material Evidence (3)
401. Human Evolution: Theory and Process (3)
402. Human Ecology (3)
403. Applied Physical Anthropology (3)
405. Primatology (3)
420. Archaeology of the Near East (3)
421. Archaeology of the Central Andes (3)
422. Archaeology of Meso-America (3)
423. Archaeology of Eastern United States (3)
440. Ethnology of South America (3)
443. Ethnology of the Old World (3-6)
444. Ethnology of Meso-America (3)
446. Ethnology of North America (3)
447. Ethnology of Sub-Saharan Africa (3)
449. Ethnology of Southeast Asia (3)
450. Comparative Social Organization (3)
451. Economic Anthropology (3)
453. (Soc. 453) Primitive Religion (3)
455. Culture and Personality (3)
456. Cultural Ecology (3)
457. Language in Culture (3)
460. Anthropological Theory (3)
461. Methods in Cultural Anthropology (3)
462. Methods in Archaeology (3)
463. Field Linguistics (3)

501. Evolution of Human Behavior (3) The application of evolutionary theory to the study of man's structure, function, and culture. Prerequisites: Anthy. 21 or 401, and 3 additional credits in anthropology, sociology, or psychology.

502-503. Ecological Theory in Anthropology (3 each) Man's biology, culture history, and culture variation from the ecological perspective. Two-term enrollment required. Prerequisite: 6 credits in anthropology.

504. Applied Anthropology (3) Methods and results of studies in which anthropological theory was applied to current problems in human biology and culture.

505. Naturalistic Behavior of Nonhuman Primates (3) Comparative study of behavior including taxonomy, geographic distribution, ecology, territoriality, population composition, grouping patterns, individual and group interactional characteristics, communication.

506. Cultural Dynamics (3) Survey of the major theories of culture change with special reference to archaeological research.

507. The Biology of Human Adaptability (3) An exploration of the biological mechanisms which aid man's survival in a variety of environmental settings.

508. Research Problems in Culture History (3)

509. Seminar in Regional Studies (3-6) Research and analysis in selected world cultural areas, including ecology, pre-history, history, ethnography, and current status.

510. World Ethnographic Survey (3) General survey of world cultures and their historical development.

ANTHROPOLOGY

530. Individual Readings in Anthropology (1-6) Reading or research in selected aspects of general anthropology.

531. Individual Research in Anthropology (3-6)

545. Seminar in Anthropology (1-9) Critical analysis of research in selected areas of anthropology.

560. Anthropological Theory (3) Theory used in culture-historical, sociological, and psychological interpretations.

561. Field Methods in Anthropology (3-9) Individual field work in any aspect of anthropology, supervised by staff of professorial rank.

562. Laboratory Methods in Anthropology (3-9) Supervised laboratory research, utilizing materials from physical anthropology or archaeology or cultural anthropology.

563. Seminar in Linguistic Anthropology (3-6) Organized research on special topics in linguistic anthropology.

ARCHITECTURAL ENGINEERING (A E)

Gifford H. Albright, *Head of the Department*
101 Engineering A Building

Degree Conferred: M.S.

Graduate Faculty, Senior Member: Professor McLaughlin.
Graduate Faculty, Associate Member: Associate Professor Albright.

Students may specialize in structural analysis and design, environmental control engineering, illumination, acoustics, materials of construction, computer application to building design and performance, or nuclear defensive and protective construction. The latter area includes shelter planning, effects of nuclear weapons, shelter environmental requirements, analysis and design of blast-resistant structural systems, and integrated engineering requirement for protective construction.

For admission a student must have a strong background in some field of engineering; in engineering science or mechanics; or in architecture, psychology, economics, or management if there is adequate preparation in the physical sciences and mathematics. The detailed requirements depend upon the student's area of special interest.

Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

ARCHITECTURAL ENGINEERING (A E)

401. Architectural Engineering (3)
402. Architectural Engineering (3)
403. Architectural Engineering (3)
430. Architectural Engineering (3)
431. Architectural Engineering (3)
439. Architectural Engineering (3)
441. Integration of Architectural Engineering Systems (3)
442. Research in Architectural Engineering (1-6)

454. Environmental Engineering in Buildings—Design (3)
458. Advanced Architectural Acoustics and Noise Control (3)
464. Advanced Architectural Illumination Systems Design (3)
481. Architectural Engineering Thesis (2)
482. Architectural Engineering Thesis (2)
483. Architectural Engineering Thesis (2)
486. Professional Engineering Practice (3)

502. Architectural Engineering (3-8) Advanced structural design in steel and reinforced concrete. Lectures and class criticism. Practicum and seminar.

503. Architectural Engineering (4-8) Continuation of A.E. 502 in which problems of wind bracing in tall buildings, rigid frames, and heavy-framed constructions are studied. Practicum and seminar.

542. Advanced Problems and Research in Architectural Engineering (2-12) Investigation, analysis, and preparation of comprehensive report on subject relating to special problems in architectural engineering systems.

545. Architectural Engineering Seminar (1-6) Current literature and special problems in architectural engineering; presentation of technical papers.

551. Advanced Nuclear Defense Planning and Design I (3) Weapons effects data; dynamic strength of materials and structural elements; dynamic design; architectural, structural, electrical, and mechanical requirements for shelters. Prerequisites: A.E. 4, 5; E.Mch. 12.

552. Advanced Nuclear Defense Planning and Design II (3) Blast-resistant design of framed structures, shear wall structures, arches, domes, and underground structures; radiation shielding characteristics of building materials. Prerequisites: A.E. 431, 432, 551; Phys. 237.

553. Selected Problems in Nuclear Defense Research (1-6)

ARCHITECTURE (ARCH)

Raniero Corbelletti, *Head of the Department*
308 Sackett Building

Degree Conferred: M.S.

Graduate Faculty, Senior Member: Professor Corbelletti.
Graduate Faculty, Associate Member: Professor Hallock.

Advanced studies are offered in architecture, urban design, and planning. The student is offered opportunity for independent research and extensive interdisciplinary work under the guidance of specialists and scholars in technical, cultural, industrial, and social fields.

For admission, a five-year bachelor's degree program in architecture is required.

Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

ARCHITECTURE (ARCH)

408-409-410. Applied Architectural Design (5 each)
420. Architectural Research (1-12)

441. Architectural Design Analysis (3)
442. Architectural Design Analysis (3)
443. Architectural Design Analysis (3)
464. Architectural Systems—Comparative Analysis of Structure (1)
475. Architectural Systems—Environmental Control (2)

501. Architectural Design (4-8) Problems in advanced planning and design, including study of group composition. Practicum and seminar.

502. Architectural Research (2-12) Prosecution of assigned problems under the guidance of an instructor.

ART (ART)

Wirth V. McCoy, *Head of the Department*
210 Arts Building

Degrees Conferred: M.A., M.F.A.

Graduate Faculty, Associate Members: Professors Altman, Fraenkel, McCoy, and Zoretich; Associate Professors Adams, Cook, Frost, Montenegro, and Shobaken.

The M.A. program is planned to provide a broad range of experience and study in the visual arts. A thesis in an area of specialization is required. Requirements for admission include a broad undergraduate training in art and the presentation of a portfolio or examples of the student's work.

The M.F.A. program is planned to provide professional emphasis in a specific area of art. A creative project and supporting monograph are required. Requirements for admission include 24 credits in studio art with some indication of concentration in a chosen area and a statement of purpose concerning the professional aims of the candidate. A portfolio, photographs, or examples of the student's work must be presented.

All students accepted for graduate study in art who lack the adequate undergraduate courses or show deficiencies in some area will be required to take additional course work without degree credit.

Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

ART (ART)

411. Seminar in Art (3)
412. Individual Instruction (3)
*425. Advanced Drawing (3)
*430. Advanced Sculpture (3)
*448. Advanced Printmaking (3)
*450. Advanced Painting (3)
*460. Advanced Watercolor (3)
470. Graphic Design II (3)
471. Graphic Design III (3)
472. Exhibition Concepts and Structure (3)
473. Seminar in Design Research (3)
*480. Advanced Ceramics (3)
495. Advanced Photography (3)

* May be repeated for a total of 12 credits.

501. Art Research (2-6) Original study and practice in art relating to material, concept, or technique.

530. Advanced Sculpture (3-12) Individual projects in sculpture leading to the development of a collection or body of work representative of the artist.

545. Printmaking (2-12) Problems in printmaking leading to the development of a collection or body of work representative of the individual artist.

550. Painting (2-12) Individual problems in painting leading to the development of a collection or body of work representative of the artist.

570. Design (2-12) Individual projects in design with special emphasis on professional practice in specialized fields of graphic design.

580. Ceramics (2-12) Experimental problems in ceramics leading to the development of a collection or body of work representative of the individual.

ART EDUCATION (A ED)

Edward L. Mattil, *Head of the Department*
269 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors Beittel and Mattil, Associate Professor Edmonston.
Graduate Faculty, Associate Members: Professor Chomicky; Associate Professors Bradley, Schwartz, and Stewart.

Graduate programs in this field prepare students for careers in public school art teaching, art supervision, college teaching, administration, or research. To be admitted without deficiencies, the student is expected to have completed either a baccalaureate program in art education or a program leading to certification. Such a program would include work in art studio, art history, art education, education, educational psychology, and psychology. Deficiencies may be made up by course work which is not counted as credit toward an advanced degree.

All students are expected to complete two years of teaching before receiving the doctor's degree. Knowledge of one or more foreign languages is an option but is not required of all candidates.

A student selected within the limitations of department facilities must meet a minimum requirement of 2.50 junior-senior average. His transcripts should indicate high attainment in appropriate academic and creative work, and his recommendations should attest to his scholarship and his ability to work independently. His creative work, as shown by slides and photographs, should show a high level of involvement and sensitivity to aesthetic forming processes. Exceptions to these requirements may be made for the student with special backgrounds, abilities, and interests.

A student who has earned a graduate degree in Art Education from The Pennsylvania State University and seeks admission to the doctoral program must make formal application to the Admissions Committee of the Department of Art Education.

ART EDUCATION (A ED)

404. Methods of Graphics and Illustrations (3)
414. Advanced Crafts for Teachers (3-6)
420. Ceramics for Teachers (3)

434. Art Appreciation in the Educational Program (3)
435. Art in the Elementary School (3)
436. Art in the Secondary School (3)
486. Current Problems in Art Education (2-3)
487. Mural Painting in Schools (3)
488. Advanced Mural Painting in Schools (3)
489. Art Experiences with Children (3)
498. Introduction to Research in Art Education (3)

501. Seminar in Art Education (1-6) The analysis of fundamental concepts derived from related disciplines; the examination of current problems; current literature.

504. Advanced Methods in Graphic Processes (3) Exploration through laboratory experience of printing method: etching, silk screen, linoleum, or other; applications in teaching.

514. Functional Relationships in Crafts (3) Relationships of material design and purpose in crafts discussed by means of outstanding products of different materials, periods, and cultures. Prerequisite: 6 credits in crafts or 3 in design and 3 in advanced crafts.

516. Analysis of Three-Dimensional Processes in Art (3) Three-dimensional processes analyzed with regard to kinetic, textural, form, and other functions.

520. Advanced Ceramic Art (3) Intensified exploration of throwing, glazing, and firing processes as related to aesthetic considerations in contemporary art forms and past cultures. Prerequisite: A.Ed. 420.

535. Administration and Supervision of Art Education Programs (3) The problems and responsibilities of the city, county, and state art supervisor; curriculum, facilities, financing, supervision, in-service training, and reporting. Prerequisites: A.Ed. 435, 436.

536. Curriculum Development in Art Education (3) Factors affecting art curriculum decisions, analysis, selection, organization, preparation of curriculum. Evaluation and sources of art curriculum improvement and innovation. Prerequisite: 6 credits of methods.

588. History of Art Education (3) Historical development of philosophies in art education in the United States and abroad.

597. Research in Art Education (1-6) Independent research, under an adviser, to be terminated by a scholarly report proportionately comparable in quality to a master's thesis. Prerequisite: 15 credits in art education on the 400 and 500 levels, including A.Ed. 598.

598. Research Methods in Art Education (3-6) Orientation in research methods; findings and designs related to the study of problems in art education.

ART HISTORY (ART H)

WINSTON R. WEISMAN, *Head of the Department*
229 Arts Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty, Senior Members: Professors Battisti, Enggass, Hyslop, and Weisman; Associate Professors Cutler and van der Meulen.
Graduate Faculty, Associate Member: Associate Professor Mauner.

Graduate work is offered in the following areas: modern, Renaissance and Baroque, medieval, Byzantine, ancient. Special research opportunities are available through the Center for the Study of Renaissance and Baroque Art.

Candidates for the M.A. are required to complete a master's thesis and to demonstrate a reading knowledge of at least one foreign language, or comprehensive knowledge of one. Candidates for the Ph.D. degree must pass a written comprehensive examination upon completion of their course work and, usually, before beginning the dissertation. They must also demonstrate a reading knowledge of two foreign languages. The department normally requires that the student take German and either French or Italian. Other languages may be substituted with the approval of the adviser.

For admission a minimum of 18 credits in art history is required. Lacking these, a promising candidate may be accepted on condition that he make up the deficiency without graduate degree credit. Applicants presenting more than a 3.00 average in their junior and senior years, and who present strong backgrounds in courses related to the major, are the group from which new students are selected within the limitations of departmental facilities. Exceptions to these requirements may be made for students with special backgrounds, abilities, and interests.

ART HISTORY (ART H)

400. STUDIES IN ART HISTORY (3-6 per term)
401. STUDIES IN GREEK ART (3)
402. THE ILLUMINATED MANUSCRIPT (3)
405. PIONEERS OF MODERN ARCHITECTURE (3-6)
410. TASTE AND CRITICISM IN ART (3)
411. ART OF IMPERIAL ROME (3)
412. THE GOTHIC CATHEDRAL (3)
414. STUDIES IN ITALIAN BAROQUE ART (3-9)
415. THE SKYSCRAPER (3)
416. AMERICAN PAINTING: 1876-1913 (3)
422. STUDIES IN MEDIEVAL SCULPTURE (3)
423. STUDIES IN ITALIAN RENAISSANCE ART (3-9)
424. MASTERS OF NORTHERN BAROQUE ART (3)
425. MOVEMENTS IN 19TH CENTURY ART (3)
435. MOVEMENTS IN 20TH CENTURY ART (3-6)

500. METHODS OF RESEARCH (3-6) Methods of art-historical research with emphasis on bibliographic and photographic resources.

510. STUDIES IN ART HISTORY (3-6 per term) Original investigation in art history, to be pursued independently or concurrently with course work in particular fields.

511. SEMINAR IN ANCIENT ART (3-12) Selected topics from the history of Greek and Roman art.

512. Seminar in Medieval Art (3-12) Original research into problems dealing with the art of the Middle Ages.

513. Seminar in Renaissance Art (3-12) Investigations in the area of Renaissance art, centering around major masters and monuments.

514. Seminar in Baroque Art (3-12) Investigations in the area of Baroque art centering around major masters and monuments.

515. Seminar in Modern Art (3-12) Lectures, readings, reports, and discussions in the field of modern art.

517. Seminar in Eighteenth Century Art (3-12) Investigation into themes and problems dealing with eighteenth century art.

522. Seminar in Byzantine Art (3-12) Specific iconographical and stylistic problems in Byzantine art and its relation to classical antiquity, the medieval West, and Islam.

525. Seminar in Modern Architecture (3-12) Investigation into the works and problems of modern architecture as they relate to the culture of our times.

590. Art History Field Seminar (3-12) Investigations based on on-the-site study of specific art objects, with trips in successive years to different art centers.

ASTRONOMY (ASTRO)

John P. Hagen, *Head of the Department*
103 Whitmore Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Hagen and Matsushima, Associate Professors Mjolsness and Sampson.
Graduate Faculty, Associate Members: Associate Professors Bauer and Zabriskie, Assistant Professor Winkler.

Opportunities are available to prepare for research or teaching. The principal research facilities of the department are in radio astronomy, but work can be done in meteors, astrophysics, and in various phases of theoretical astronomy. Modern astronomy has very close ties with mathematics, physics, and engineering. The program required of a doctoral candidate would normally include courses in at least two of these related fields, in addition to those in astronomy.

A bachelor's degree in astronomy, physics, mathematics, or related branches of engineering is required for admission. Opportunity to make up possible undergraduate deficiencies is provided.

Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

ASTRONOMY (ASTRO)

430. General Astronomy for Teachers (3)
460. Fundamentals of Celestial Mechanics (3)
470. Solar Physics (3)
490-491. Introduction to Astrophysics (3 each)

492. Space Astronomy (3)
495. Practical Astronomy (3)

510. Astrophysics (3) An introduction to astrophysics in which the relevant physics, spectra, gas laws, plasmas, and radiation transfer theory are discussed.

511. Astrophysics (3) Stellar atmospheres; considerable emphasis is placed on the sun and on solar-terrestrial relationships. Prerequisite: Astro. 510.

512. Astrophysics (3) Stellar interiors, stellar evolution, pulsating stars, novae and supernovae; some discussions of the interstellar medium and gaseous nebulae. Prerequisite: Astro. 510.

513. Observational Techniques in Astronomy (3) Radiation quantities in theory and as observed. Astrometry, photometry, spectroscopy, stellar classification, interferometric methods. Observational laboratory. Prerequisite: Astro. 511.

516. Non-equilibrium Radiative Transfer Theory (3) Detailed study of theory of radiative transfer when the assumption of local thermodynamic equilibrium is not made, with astrophysical applications. Prerequisite: Astro. 511 or Phys. 561.

520. Galactic Structure (3) Stellar clusters and associations, galactic dynamics, stellar populations, distance determinations, luminosity calibration, and stellar statistics.

522. Spherical Astronomy (3) Astronomical coordinate systems, Kepler's equation, aberration, parallax, precession and nutation, time, eclipses and occultations, and solar motion.

523. Observational Theory (3) Information theory of noisy signals, statistics of nonlinear functions, theory and application of convolutions, selection effects, systematic errors, selected problems. Prerequisite: Astro. 513.

525. Double Stars (3) Two-body theory; analysis of visual, astrometric, spectroscopic, and eclipsing binaries; and discussions of particular systems. Prerequisite: Astro. 522.

530. Theory of Stellar Atmospheres (3) Theory of photospheric structure, radiative processes, and line-formation in the outer layers of stars, and interpretation of stellar spectra. Prerequisite: Astro. 511.

534. Stellar Structure and Evolution (3) A detailed study of the theory of the interiors and evolution of stars. Prerequisite: Astro. 511 or Phys. 561.

542. Gaseous Nebulae and Interstellar Matter (3) Theory and observations of galactic nebulae and interstellar medium, and problems related to the formation of stars and galactic structure. Prerequisite: Astro. 511.

545. Astrophysical Plasma Kinetic Theory (3) Kinetic theories, fluid behavior, collective phenomena, and collisional processes of plasmas and self-gravitating systems of gas and stars. Prerequisite: Phys. 530.

560-561. General Relativity and Cosmological Models (3 each) Riemannian geometry; general relativity theory and experiments; massive bodies; and Newtonian, Einsteinian, and steady state cosmologies are studied. Prerequisite: Phys. 525.

582. Radio Astronomy (3) Radiometers and antennas; signals in noise; solar physics; quiet and active solar radiation; transfer equation and solar radiation; solar-terrestrial effects. Prerequisite: E.E. 438 or Phys. 467.

583. Radio Astronomy (3) Radio astronomical studies of the moon and planets,

galactic and extragalactic sources, and the structure of galaxies using line spectra. Prerequisite: Astro. 582.

590. Special Topics (1-3 per term) Theoretical studies in any field of modern astronomy or astrophysics, with or without associated experimental work. Prerequisites: Astro. 510, 511, 512.

BIOCHEMISTRY (BIOCH)

John H. Pazur, *Head of the Department*
109 Frear Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Clagett, Mallette, and Pazur; Associate Professors Phillips and Shigley; Assistant Professors McCarl and R. Schraer.
Graduate Faculty, Associate Members: Assistant Professors Niehaus and Winter.

Opportunities for research and graduate study are available in intermediary metabolism, cellular control mechanisms, molecular genetics, enzyme structure, nucleic acids, proteins, carbohydrates, lipids, photosynthesis, and endocrinology.

Entering graduate students should have had at least one year's work in each of the following: general chemistry, analytical chemistry, organic chemistry, physical chemistry, and general physics. Mathematics through integral calculus is also required. Students with limited deficiencies in these subjects may be admitted but must make up such deficiencies concurrently with their graduate studies. Undergraduate courses in biology, biochemistry, and foreign languages will be helpful to the student but are not required for admission.

Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

The Corn Products Lectures in Biochemistry enable the department to bring to the campus each year some distinguished visiting lecturers.

For courses offered at The Milton S. Hershey Medical Center see the Medical Center catalog which may be obtained by contacting the Dean of the College at The Milton S. Hershey Medical Center, Hershey, Pennsylvania 17033.

BIOCHEMISTRY (BIOCH)

401. General Biochemistry (3)
402. General Biochemistry (3)
403. Experimental Biochemistry (3)
404. Food Chemistry (3-4)
417. Biochemical Methods (4)
425. Biophysical Chemistry (4)
436. Physiological Chemistry (3)
437. Physiological Chemistry (3)
438. Clinical Methods (3)
439. Independent Study (1-12)

501. Enzymes (2) Investigations and theories concerning nature of enzymes, enzyme action, influence of chemical environment on enzyme action, and biological applications. Prerequisite: Bioch. 402 or 437.

503. Biochemical Problems (1-10 per term) Prosecution of an assigned problem under the guidance of an instructor.

507. Seminar in Biochemistry (1 per term)

510. Proteins, Amino Acids, and Peptides (2) Organic, physical, and biological chemistry of the naturally occurring compounds of this group. Prerequisites: Bioch. 425; 402 or 437.

511. Carbohydrates (2) Chemical constitution and properties of carbohydrates; their metabolism in plant and animal organisms. Prerequisite: Bioch. 402 or 437.

512. Lipids (2) Investigations on biochemistry of fats and related substances.

516. Chemistry of the Pesticides (2) Lectures and assigned readings on the chemistry of insecticides, fungicides, herbicides, rodenticides, and related materials. Prerequisites: Chem. 31; Bioch. 402 or 437.

517. Endocrine Secretions (2) Chemistry of hormones and their physiological significance. Prerequisite: Bioch. 402 or 437.

519. Intermediary Metabolism (3) Processes involved in the utilization of metabolites in plants and animals. Prerequisite: Bioch. 402. Spring term.

520. Biochemical Methods (3) Lectures and advanced laboratory on current techniques pertaining particularly to research on proteins and enzymes. Prerequisite or concurrent: Bioch. 501, 510.

521. Biochemical Methods (3) Lectures and advanced laboratory on current techniques pertaining particularly to research on lipids and carbohydrates. Prerequisite or concurrent: Bioch. 511, 512.

530. Special Topics in Biochemistry (2-4)

BIOLOGICAL CHEMISTRY (BCHEM)

Louis F. Hass
In Charge of Graduate Programs in Biological Chemistry
The Milton S. Hershey Medical Center

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professor Davidson, Associate Professors Hass and Rosenberg.
Graduate Faculty, Associate Members: Assistant Professors Hill, Miljkovic, and Murray.

Opportunities for research and graduate study are available in the chemistry and metabolism of complex polysaccharides, cellular differentiation, mechanism of enzymatic reaction, biochemical genetics, biochemistry of complex lipids, and confirmational analysis of carbohydrates and proteins.

Qualified students with undergraduate preparation in biological or physical sciences may apply. Entering graduate students should have at least one year's work in each of the following: general chemistry, analytical chemistry, organic chemistry, physical chemistry, general physics, and mathematics through integral calculus. Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

BIOLOGICAL CHEMISTRY

Research and graduate study opportunities are also available in the Department of Biochemistry at University Park. Course listings may be found on pages 94 and 95.

BIOLOGICAL SCIENCE (BI SC)

ANTON J. KOVAR, *Chairman of the Committee on Biological Science*
311 Life Sciences Building

Degrees Conferred: D.Ed., M.Ed.

Graduate Faculty, Senior Members: Professors Anthony, Cheng, Cooper, Fergus, Grun, Hale, Kovar, and Wright; Associate Professors Bellis, Hamilton, Hillson, Hymer, and Wickersham.
Graduate Faculty, Associate Members: Associate Professors Pursell and Wood, Assistant Professors Neff and Witham.

The M.Ed. program in biological science is designed primarily to meet the needs of secondary school science teachers. The academic degrees M.S. and Ph.D. are not offered in biological science but are available in biochemistry, biophysics, botany, entomology, genetics, microbiology, physiology, plant pathology, and zoology.

The candidate for the M.Ed. degree must earn at least 21 credits in the natural sciences with a minimum of 15 credits in the biological sciences, including at least 6 in the animal sciences and 6 in the plant sciences. In addition, at least 6 credits in educational foundations and a term paper are required.

The D.Ed. program is designed for secondary school and college science teachers. Major course requirements are designated by the candidate's committee with the concept that teachers of biology have a broad background in biological disciplines and related fields. A minimum of 15 credits each is required in professional education and in thesis research. The requirement of a foreign language is at the discretion of the candidate's committee.

In order to enter a program for a higher degree with a major in biological science, the candidate should present 30 credits in the natural sciences, including one year of organic chemistry and one year of physics. A limited number of undergraduate deficiencies may be made up in pursuit of the advanced degree. Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

BIOLOGY (BIOL)

JOSEPH G. O'MARA, *Head of the Department*
115 Life Sciences I Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Anthony, Cheng, Cooper, Dalton, Fergus, Grove, Grun, Hale, Kneebone, Kovar, O'Mara, Schein, and Wright; Associate Professors Bellis, Butler, Hamilton, Hibbard, Hillson, Hymer, Traverse, and Wickersham; Assistant Professors Dunson, Henshaw, and Wagner.
Graduate Faculty, Associate Members: Associate Professors Pursell and Wood; Assistant Professors Abplanalp, Costantino, Keener, Lennox, Neff, Therrien, and Witham.

The department will direct graduate programs in behavior, cell biology, cytology, cytochemistry, environmental science, ultrastructure, and other aspects of modern biology. The courses of study are planned individually by the student and an adviser. Admission is restricted to students who have the baccalaureate degree in a biological science and who present a 2.80 junior-senior average. Exceptions to the requirements for admission can be made for students with degrees in related subjects who will remedy their undergraduate deficiencies concurrently with their graduate studies.

BIOLOGY (BIOL)

400. Comparative Plant Morphology (4)
401. (Pty.Sc. 401, Psy. 401) Animal Behavior (3)
402. Vertebrate Neuroanatomy (3)
403. (Ent.) Systematics (3)
405. General Cytology (3)
407. Plant Anatomy (3)
408. Mammalogy (4)
410. General Limnology (3)
411. Plant Biology for Teachers (3)
412. Plant Biology for Teachers (3)
414. Advanced Systematic Botany (3)
415. The Literature of Zoology (1)
416. The Methods of Research in Zoology (2)
417. Invertebrate Zoology (3)
418. Mycology (3)
419. General Animal Ecology (3)
420. (Geol. 420) Paleobotany (3)
421. Comparative Anatomy of Vertebrates (4)
422. Advanced Genetics (3)
423. (Geol. 423) Introductory Palynology (3)
424. Botanical Technique (3)
428. The Genetical Theory of Natural Selection (3)
430. (Bphys. 430) Molecular Biology of the Gene (3)
437. Histology (4)
440. Embryology (4)
441. Plant Physiology (3)
442. Plant Physiology (3)
443. Plant Physiology (3)
444. Zoological Problems (1-6)
445. Plant Growth Substances (3)
448. Ornithology (3)
450. Plant Autecology (3)
451. Plant Synecology (3)
452. Ichthyology (3)
461. Animal Parasitology (3)
470. Comparative Environmental Physiology (4)
471. Vertebrate Physiology (3)
475. Cellular Physiology (4)
479. General Endocrinology (3)
480. Marine Biology (4)
481. Aquatic Botany (3)

500. Plant Physiology Seminar (1 per term) Selected topics from recent literature; staff and student reports on current research. Spring term, even years.

501. Evolution (3) Selected topics on the evolution of life.

502. The Physiology of the Fungi (3) Chemical composition, metabolism, toxic

and stimulating agencies, spore germination, growth and irritability of the fungi. Fall term, even years.

505. Cytology and Cytogenetics (3) Chromosome mechanism of heredity; relationship between plant and animal evolution and breeding and changes in chromosomes; cytological and cytochemical techniques. Prerequisite: Biol. 405 or 422.

506. Comparative Anatomy of Vascular Plants (3) Structure of the Tracheophyta from a phylogenetic standpoint. Prerequisite: Biol. 407. Spring term, even years.

509. Techniques in Wildlife Management (2) Evaluation of procedures designed to manage populations of game and fish; elements of statistics of birth and mortality rates; census methods. Fall term.

511. Advanced Plant Physiology (3) Physiology of plants including uptake of water and minerals, translocations, mineral nutrition, energy relations, respiration, and catabolism. Prerequisite: Biol. 442. Fall term.

512. Advanced Plant Physiology (3) Continuation of Biol. 511. Physiology of plants including photosynthesis, synthesis of cellular constituents, growth and development. Prerequisite: Biol. 442. Winter term.

513. Biology Seminar (1 per term) Presentation and discussion of selected topics.

516. Ecological Plant Geography (3) Distribution of plant communities; environmental factors which influence their present distribution; geological-historical development of plant communities, their past distribution. Winter term, odd years.

518. Special Problems (1-6) Prosecution of an assigned problem under the guidance of a staff member. Throughout the year as arranged. By appointment.

521. Medical and Industrial Mycology (3) Structure, life histories, classification, and techniques of study of the fungi pathogenic to man and of fungi important in industry. Fall term, odd years.

522. Myxomycetes, Phycomycetes, and Ascomycetes (4) Morphology, taxonomy, phylogeny, and life histories; identification and field work. Prerequisite: Biol. 418. Winter term, even years.

523. Basidiomycetes and Fungi Imperfecti (4) Morphology, taxonomy, phylogeny, and life histories. Prerequisite: Biol. 418. Spring term, even years.

524. Seminar in Genetics (1 per term)

525. Genetics of Fungi (3) Selected topics including mutagenesis, DNA repair mechanisms, gene action, complementation, meiotic recombination, parasexuality, heterocaryosis and cytoplasmic inheritance. Prerequisites: 3 credits in genetics and 3 credits in biochemistry.

526. (Geol. 526) Problems in Palynology (1-6) Systematics; paleoecological palynology; Paleozoic palynology; Mesozoic and Cenozoic palynology; Pleistocene vegetational history.

528. Biometrical Genetics (3) Hereditary structure of populations fusing the principles of genetics, mathematics and statistics, genetic analysis of quantitative traits, artificial selection theory. Prerequisites: Biol. 428 and Stat. 402 or Agro. 545.

531. Bryology (3) Morphology, taxonomy, and ecology of liverworts, hornworts, and mosses; collection, preservation, culturing, and cytologic techniques. Spring term, even years.

533. Problems in Genetics (2-6) Problems to suit needs of individual students; conferences and laboratory work.

535. Morphology of the Tracheophyta Exclusive of Angiosperms (3) Origin, developmental tendencies, structure, and paleobotanical evidence. Winter term, odd years.

536. Morphology of Angiosperms (3) Floral origin and development, fertilization, embryogeny, seeds and fruit development. Prerequisite: Biol. 400.

537. (Sec.Ed. 537) Workshop in the Biological Sciences (3) Projects designed for teachers of biology in the secondary schools. Summer term only.

538. Principles of Microscopic Histochemistry (2) Theoretical basis for the microscopic identification, localization, and quantitative analysis of chemical substances in tissues of organisms. Prerequisite: Biol. 405 or 437.

539. Analytical Histochemistry Laboratory (2-4) Application of histochemical techniques in the microscopic analysis of tissue lipids, proteins, carbohydrates, nucleic acids and proteins. Prerequisite or concurrent: Biol. 538.

540. Phycology (4) Comparative morphology, taxonomy, and ecology of fresh water and marine algae; culturing, collection, preservation techniques. Prerequisite: Biol. 424.

541. Comparative Physiology (3) Phylogenetic variation in the regulation of the internal environment of animals.

546. Principles of Animal Populations (3) Ecological laws governing population growth and decline; reproductive and mortality rates; predation and composition as limiting factors. Fall term.

571. (Phsio. 571) Animal Physiology (2) Physiology of fluid transport mechanisms; examination of the distribution and regulation of body fluids, blood, and hemodynamics. Prerequisite: 3 credits in physiology.

572. (Phsio. 572) Animal Physiology (2) Examination of nutrition, metabolism, and respiration as they relate to subcellular, cellular, and organ organizational levels of the whole animal. Prerequisite: 3 credits in physiology.

573. (Phsio. 573) Animal Physiology (2) Detailed examination of animal reproduction, endocrine secretion and control, neural muscular activity, central nervous system correlates, and special senses. Prerequisite: 3 credits in physiology.

574. (Phsio. 574) Animal Physiology Laboratory (1-6) Selected problems using advanced physiological techniques to study transport mechanisms, circulation, excretion, respiration, metabolism, and neuroendocrines. Prerequisites: Phsio. 571, 572. Prerequisite or concurrent: Phsio. 573.

575. Advanced Cell Physiology (3) Current topics and experiments in cell physiology.

581. Advanced Invertebrate Zoology (3) Morphology, physiology, taxonomy, and life histories of invertebrate animals.

582. (Pty.Sc. 582, Psy. 582) Research in Animal Behavior (2-6 per term) Research in special areas of animal behavior involving field or laboratory work.

583. Experimental Endocrinology (4) Problems in endocrinology designed to demonstrate the role of hormones in the regulation of physiological phenomena.

BIOPHYSICS (BPHYS)

ERNEST C. POLLARD, *Head of the Department*
618 Life Sciences Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Ginoza, Person, Pollard, and H. Schraer; Associate Professors Deering, Morgan, Smyth, Snipes, Strother, and Taylor; Assistant Professor Todd.
Graduate Faculty, Associate Members: Assistant Professors Rake and Scheie.

This program is designed for those interested in applying physical methods to the problems of living systems. A student with a degree in physics, biology, chemistry, or engineering is eligible for admission. Opportunity to make up possible undergraduate deficiencies is provided in the program.

Courses are offered in molecular biophysics (an introductory course), nucleic acids, radiation action, cellular physiology, biophysical instrumentation, general biophysics, physics of viruses, and physics of the cell. Advice on the selection of other courses to meet the needs of each student is provided by the faculty. These include courses in physics, chemistry, biochemistry, zoology, botany, and microbiology.

BIOPHYSICS (BPHYS)

410. SPECIAL TOPICS (1-6)
430. (Biol. 430) MOLECULAR BIOLOGY OF THE GENE (3)
473. INTRODUCTORY BIOPHYSICS (3)
474. MOLECULAR BIOPHYSICS I (3)
475. MOLECULAR BIOPHYSICS II (3)

580. BIOPHYSICAL SCIENCE (3) Enzyme kinetics; thermodynamics of biological systems; molecular theory of reaction rates; structural aspects of biological reactions. Prerequisite: Bphys. 474 or Chem. 451.

581. RADIATION BIOPHYSICS (2) The action of ionizing radiation decay on biological systems: molecular and cellular aspects. Prerequisite: Bphys. 475.

582. BIOPHYSICS OF NUCLEIC ACIDS (3) Biophysical studies on the structure and function of the nucleic acids, particularly those of bacterial and viral origin.

583. SPECIAL TOPICS IN BIOPHYSICS (1-6 per term)

584. SEMINAR IN BIOPHYSICS (1-3 per term)

585. BIOLOGICAL ULTRASTRUCTURE (4) The application of electron microscopy to the study of cell biology. Prerequisite: any of the following—Bphys. 473; Biol. 405, 437; Micrb. 401.

586. BIOLOGICAL MACROMOLECULES (3) Biopolymer characteristics; polymer statistics; size and shape determination; methods of separation; polyelectrolytes; optical and mechanical properties; denaturation; degradation; biosynthesis. Prerequisite: Bphys. 475 or Chem. 451.

587. ULTRACENTRIFUGATION (2) A laboratory course in ultracentrifugation techniques including applications to biophysical problems. Prerequisite: Bphys. 475.

588. PHYSIOLOGY OF NERVES, MUSCLES, AND SENSE ORGANS (2-6) Current literature on the function of excitable tissues of insects and other animals. Prerequisite: a 400-level course in physiology, biophysics, or physiological psychology.

589. Mammalian Cell Culture (3) Recent research in quantitative cell biology as studied with tissues and cells of higher organisms cultured *in vitro*. Prerequisite: Bioch. 401.

590. Photobiology (2) Effects of visible and ultraviolet light on biological systems: energy absorption, transfer, utilization; photochemistry; metabolic and genetic responses; repair systems.

591. Microspectrophotometry (2) Principles of absorption spectroscopy; microspectrophotometer design; determination of cellular constituents using stained and unstained preparations; laboratory exercises. Prerequisite: graduate student standing.

595. Electron Spin Resonance Spectroscopy (3) Experimental and theoretical aspects of electron spin resonance spectroscopy to provide ability for its application to biophysical problems. Prerequisite: basic knowledge of quantum mechanics and electromagnetic waves.

BOTANY (BOT)

C. Leonard Fergus
In Charge of Graduate Programs in Botany
202 Buckhout Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Fergus, Grove, Grun, Kneebone, Kovar, O'Mara, Schein, Spackman, and Wright; Associate Professors Hamilton, Hillson, and Traverse; Assistant Professor Wagner.

Graduate Faculty, Associate Members: Associate Professor Pursell; Assistant Professors Costantino, Keener, Lennox, Therrien, and Witham.

Botanical programs are offered in plant anatomy, cytology, ecology, genetics, morphology, mycology, physiology, and taxonomy. A student having a degree in science or in one of the biological sciences is eligible for admission. Entering graduate students should have had basic courses in chemistry, mathematics, and physics.

Students who present a 2.80 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

See also Genetics and Physiology.

Note: *For courses in Botany and related subjects see Biology.*

BUSINESS ADMINISTRATION (B A)

Max D. Richards
In Charge of Graduate Programs in Business Administration
102A Boucke Building

Degrees Conferred: Ph.D., M.S., M.B.A.

Graduate Faculty, Senior Members: Professors Bradley, Carzo, Cook, Coyle, Ferrara,

Greenlaw, Kelley, McKinley, Pashek, Philips, Richards, Rigby, Schrader, Strong, Waters, and Wherry; Associate Professors Babione, Bennett, Copeland, Cramer, Hammond, Heitmann, Spier, and Yanouzas; Assistant Professor Wojdak.

Graduate Faculty, Associate Members: Professors Nelson, Phalan, and Williams; Associate Professors Beik, Carroll, Clewett, Hottenstein, Malcom, Melander, Millman, and Shilling; Assistant Professors Chase, Crumbley, and Slocum.

The M.B.A. provides a professional program for education in business administration to prepare individuals for administrative positions in business, institutional, or governmental management. Interested applicants whose undergraduate preparation has been in business or in fields other than business are encouraged to apply.

Required are preparatory courses in accounting, business law or the legal environment, business statistics, calculus, financial management, finite mathematics, macroeconomics, microeconomics, management, and marketing. The M.B.A. program itself requires 36 credits of graduate courses and a professional paper.

The M.S. and Ph.D. programs with a major in business administration are designed for those interested primarily in research and teaching.

For admission to the M.S. program, approximately 30 acceptable undergraduate credits in business administration, economics, and mathematics are required. An applicant may be admitted with deficiencies to be made up without degree credit.

Applicants are evaluated for admission on the basis of academic potential and other factors giving evidence of a high probability of completing the program. Data useful for evaluating academic potential include a 2.50 junior-senior average, ATGSB test scores, and academic recommendations.

Applicants to any of the graduate programs in business administration are required to take the Admission Test for Graduate Study in Business (ATGSB) given by the Educational Testing Service and used by leading graduate business schools throughout the country to supplement other criteria for admission. Candidates are strongly urged to take the test at the earliest possible date. It is given at University Park and at numerous locations in most states and foreign countries in November, February, April, and July. For dates and locations, see the *Bulletin of Information,* Admission Test for Graduate Study in Business, Educational Testing Service, Princeton, New Jersey. Applicants should read the bulletin carefully. All arrangements for taking the test are made directly with the Educational Testing Service.

This graduate program is accredited by the American Association of Collegiate Schools of Business.

ACCOUNTING (ACCTG)

401. Advanced Accounting (3)
403. Auditing (3)
404. Managerial Accounting (3)
406. Advanced Federal Tax Accounting (3)
409. Machine and Electronic Accounting Methods (3)

*398G. Accelerated Elementary Accounting (3) The theory and technique of financial and managerial accounting: preparation, analysis, and interpretation of financial statements. Open to graduate students only.

500. Accounting Seminar (3-6)

503. Seminar in Auditing (3) The attest function of independent public accountants, verification of financial statements; problems of evidence, independence, ethics, professional responsibilities. Prerequisite: Acctg. 403.

* No graduate credit is given for this course.

504. Seminar in Managerial Accounting (3-6) Accounting and the managerial processes of planning, control, and decision-making.

507. Seminar in Financial Accounting (3) Theoretical basis of financial accounting.

508. Contemporary Issues in Accounting (3) Selected problems of current interest to the accounting profession.

511. Interpretation of Account Data (3)

515. Development of Accounting Thought (3) Development of accounting thought from ancient civilizations to the present.

520. Problems in Accounting (3-6) Planned individual projects involving library, laboratory, or field work.

BUSINESS ADMINISTRATION (B A)

503. Seminar in Public Utilities (3)

540. Business Administration Theory and Practice (3) An integrating course primarily for M.S. students using cases requiring analysis involving interrelated aspects of business administration and control.

550. Behavioral Science in Business (3) Application of behavioral science concepts and analytical methods to problems in business organzations. Analysis of administrative behavior and decision-making.

552. Business Research Methods (3) Research methods applicable to business problems with emphasis on means of obtaining data and the logic underlying research design.

555. Business and Society (3) Evolution of the business organization and the changing framework of its operations, responsibilities, and social control.

574. Business Research (1-3) A project paper, comparable in quality and scope of work to a graduate thesis, on problems of a company. Prerequisite: 15 credits of 400 and 500 courses in business administration

577. Administrative Integration (3) An analysis of coordination of the functional areas of business in relation to over-all company objectives. Prerequisite: 15 credits of 400 and 500 courses in business administration.

BUSINESS LAW (B LAW)

*398G. Accelerated Business Law (3) Social control through law: courts; policies underlying individual rights; negotiable and non-negotiable contractual rights in society. Open to graduate students only.

BUSINESS LOGISTICS (B LOG)

410. Transportation and Public Policy (3)
412. Transportation Decision Techniques (3)
420. Urban Transportation (3)

504. Problems in Business Logistics (3-6) Planned individual projects involving library, laboratory, or field work.

* No graduate credit is given for this course.

538. Transportation and Physical Distribution (3) Control of the movement of goods; coordination of supply and demand in creation and maximization of time and place utility.

565. Seminar in Business Logistics (3-6)

FINANCE (FIN)

406. Security Analysis and Portfolio Management (3)
408. Financial Markets (3)

*398G. Accelerated Financial Management (3) Financial planning and forecasting; management of working capital, capital budgeting, and dividend policy; capital structure and valuation. Open to graduate students only.

504. Problems in Finance (3-6) Planned individual projects involving library, laboratory, or field work.

531. Financial Management (3) An intensive examination of techniques available to aid the financial manager in decision-making.

541. Financial Theory (3) A theoretical analysis of the elements of finance.

561. Seminar in Finance (3-6) Comparative analysis of research in the theories of finance; relationships to business management practices.

INSURANCE (INS)

400. Estate Planning (3)

500. Insurance Theory and Practice (3) Insurance as an institution, a technique, a legal contract; its environment as a regulated industry.

504. Problems in Insurance (3) Planned individual projects involving library, laboratory, or field work.

510. Risk Management (3) Analysis of managerial problems and responsibility for risk analysis, removal or reduction, and allocation of corporate resources to provide indemnity.

520. Seminar in Insurance (3-6) Selected topics on advanced aspects of risk management with emphasis on the insurance technique for treating hazards.

INTERNATIONAL BUSINESS (I B)

501. The International Environment (3) Conceptual approach analyzing and predicting influences of social, political, and economic norms and values upon diverse societies' managerial decision-making.

502. International Business Macro Theory and Policy I (3) International economic trade and monetary tools are applied to current national policy issues to determine effects on international business operations. Prerequisite: Econ. 333.

503. International Business Micro Theory and Policy I (3) Analysis of the internal operations of multinational firms; design of optimal strategies of operation under varying environmental conditions. Prerequisite: I.B. 502.

* No graduate credit is given for this course.

504. Seminar in International Business (3-6) Seminar techniques applied to selected topics; market structures; capital budgeting, investment; comparisons of foreign norms and values; multinational organization characteristics.

MANAGEMENT (MGMT)

420. Management of Personnel Systems (3)
430. Administrative Management (3)
432. Simulation of Management Systems (3)
435. Cases in Public Relations (3)

*398G. Accelerated Business Management (3) The concepts of management and its decision processes including special attention to operations management.

510. Operations Management (3) Integration and application of decision-making to operational and policy problems within the business firm.

515. Design of Operation Output Systems (3) Examination of research-based findings in operations management with a focus on the design and reliability of production systems.

516. Operations Planning and Control (3) Examination of research-based findings in operations management. The focus is on the operation and control of production systems.

517. Conceptual Bases of Socio-technical Systems (3) Integrates behavioral science and operations management in socio-technical framework. Design of socio-technical systems.

520. Organization Theory (3) Theoretical and operating structures in formal business organizations; relation of formal organization to informal groups and to individuals.

521. Seminar in Organizational Behavior (3) Examination of research-based findings on organizational behavior. Methodological techniques for studying human behavior in formal organizations.

531. Management Information Systems (3) Information system theories and methods applied to administrative structures and management decisions in organizations.

540. Personnel Management (3) Theoretical constructs underlying personnel administration; analysis of professional personnel functions in business firms.

590. Seminar in Management (3-6) Comparative analysis of research in the theories of the administrative sciences; relationships to business management practices.

591. Special Topics in Management (3-6) In-depth explorations of special topics of management theory.

MARKETING (MKTG)

424. Marketing Research (3)
435. Marketing and Public Policy (3)

*398G. Accelerated Marketing Management (3) Analyses of customer and market behavior, marketing systems, and competitive strategies; programming product, pricing, distribution, and promotion. Open to graduate students only.

* No graduate credit is given for this course.

500. Marketing Management (3) Analysis of management's marketing problems including market analyses, pricing, channel of distribution, promotion, competition, product strategies, and marketing research.

504. Problems in Marketing (3-6) Planned individual projects involving library, laboratory, or field work.

510. Planning Market Strategy and Programs (3) Development of marketing strategy for the firm and design of integrated product-service, promotion, and distribution programs utilizing systems analysis.

520. Quantitative Analysis for Marketing Decisions (3) Sales forecasting, new product proposals, media selection, and market testing analyzed using statistical and decision theory and other mathematical techniques.

530. Consumer and Market Behavior (3) Buying behavior: concepts from the behavioral sciences, including utility, culture, life cycle, personality, attitudes, and learning.

540. Marketing and Society (3) Marketing problems of society; domestic and regional marketing systems; governmental policies toward marketing; social performance of marketing.

544. Marketing Theory (3) The development of marketing concepts, behavioral and other marketing theories; public policy and the role of marketing in societies.

560. Seminar in Marketing (3-6) Research in modern marketing trends.

QUANTITATIVE BUSINESS ANALYSIS (Q B A)

403. Intermediate Business Statistics (3)
404. Sampling in Business Operations and Research (3)
451. Analytical Methods in Business (3)
452. Analytical Methods in Business (3)
461. Probabilistic Models in Business (3)
490. Special Topics (3-6)

*398G. Accelerated Business Statistics (3) Basic characteristics of univariate and bivariate distributions, probability theory, introduction to estimation, tests of hypotheses, and time series analysis. Open to graduate students only.

500. Seminar in Business Statistics (3-6)

501. Advanced Business Statistics (3)

510. Statistics in Business Research (3) Statistical principles and procedures essential to the interpretation and performance of research in business administration. Prerequisite: common requirements of M.B.A. program.

521. Quantitative Analysis for Business Decisions (3) Construction and use of quantitative models in business decision-making. Prerequisite: common requirements of M.B.A. program.

527. Statistical Decision Theory (3) A systematic survey and analysis of the concepts and methods of Bayesian statistical decision theory.

REAL ESTATE (R EST)

400. Urban Land Utilization (3)

* No graduate credit is given for this course.

BUSINESS EDUCATION (BUSED)

JOSEPH T. IMPELLITTERI
In Charge of Graduate Programs in Business Education
248 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professor House, Associate Professor Impellitteri.

This program provides advanced preparation for teachers of business subjects for secondary schools and colleges. The subject-matter areas encompass secretarial, accounting, retailing, clerical, and general business sequences. The program may be adapted for the preparation of supervisors of business education.

A minimum of 18 acceptable undergraduate credits in education and psychology plus a minimum of 30 credits in business and business education subjects are required for admission.

All candidates specializing in business education are encouraged to acquire a general education in the social sciences, the behavioral sciences, and the humanities.

Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

BUSINESS EDUCATION (BUSED)

456. PRINCIPLES AND PROBLEMS IN BUSINESS EDUCATION (1-3)
459. IMPROVEMENT OF INSTRUCTION IN BUSINESS SKILL SUBJECTS (1-3)
460. CURRICULUMS IN BUSINESS EDUCATION (3)
461. IMPROVEMENT OF INSTRUCTION IN BASIC BUSINESS SUBJECTS (3)
462. TEACHING OF SHORTHAND AND TYPEWRITING (3)
463. TEACHING OF BOOKKEEPING (3)

511. INTERNSHIP IN BUSINESS EDUCATION SUPERVISION (3-6) Internship to take place in schools or educational situations where student is not regularly employed, under supervision of graduate faculty.

575. ADMINISTRATION AND SUPERVISION IN BUSINESS EDUCATION (3) Work of administrators, supervisors, and others responsible for improvement of instruction in business education; use of vocational testing; job analysis. Prerequisite: 6 credits in secondary education.

576. INTRODUCTION TO RESEARCH IN BUSINESS EDUCATION (3) Methods of research in business education; opportunity to compile annotated bibliographies on current problems; analysis and evaluation of significant research.

577. EVALUATION OF RESEARCH AND EMPIRICAL LITERATURE IN BUSINESS EDUCATION (3) Application of evaluation methods to current literature in business education; special attention to research studies. Prerequisite: Bus.Ed. 576.

578. SEMINAR IN BUSINESS EDUCATION (1-6) Intended for graduate students preparing theses or final documents, or for those working on special studies in business education. Prerequisite: Bus.Ed. 577.

CERAMIC SCIENCE (CERSC)

Guy E. Rindone
In Charge of Graduate Programs in Ceramic Science
215 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Hummel, Kline, Rindone, and Williamson; Associate Professors Newnham and Stubican; Assistant Professor McKinstry.
Graduate Faculty, Associate Member: Assistant Professor Bradt.

This program is one of the options in which a graduate student in the Department of Materials Science can receive an advanced degree. In view of the wide field covered by ceramic science, the graduate courses may be selected with a bias toward physical ceramics, chemical ceramics, or glass science.

Special facilities exist for research in the areas of electroceramics, rheology, phase equilibria, solid state synthesis, mechanical properties, ferrite and ferroelectric studies, glass science, and high temperature reaction kinetics.

Suitable preparation for graduate study in this program may be found in one of the materials sciences such as ceramics, or metallurgy, in engineering fields such as chemical or mechanical engineering; in the basic physical sciences or in the earth sciences.

Students having at least a 2.50 junior-senior average and appropriate supporting information will normally be accepted subject to the limitations of the departmental facilities. Exceptions to these requirements may be made for students with special backgrounds, abilities, and interests.

CERAMIC SCIENCE (CERSC)

400.	(Min. 400) Nonmetallic Crystal Chemistry (2)	*Mr. Brindley*
402.	Principles of Ceramic Engineering (3)	*Mr. Williamson*
404.	Ceramic Seminar (1)	*Mr. Hummel*
405.	Ceramic Research and Design (1)	
406.	Rheology and Fluid Properties of Ceramic Systems (2)	*Mr. Williamson*
407.	Ceramic Materials Laboratory (2)	*Mr. Williamson*
408.	Heat Treatment of Ceramic Materials (1)	*Mr. Stubican*
409.	Heat Treatment Laboratory (2)	*Mr. Stubican*
410.	Phase Relations in Ceramic Systems (3)	*Mr. Hummel*
411.	Principles of Ceramic Processes (2)	*Mr. McKinstry*
414.	Mechanical Properties of Ceramics (3)	*Mr. Bradt*
415.	Principles of Glass Technology (3-4)	*Mr. Rindone*
420.	Refractories (2-3)	*Mr. Stubican*
425.	Ceramic Research and Design (2)	
430.	Electroceramics (2-3)	

500. Seminar in Ceramic Science (1-2 per term) Current developments in ceramic science and related fields. Required of all graduate students in ceramic science. *Mr. Hummel and Staff*

501. Colloidal Behavior of Clays and Muds (2-4) Surface chemistry of clays; rheology of ceramic powders, suspensions, and pastes. *Mr. Williamson*

503. Use of Phase Equilibria Data in Ceramic Science (2-5) Phase equilibria in unary, binary, ternary, and other systems; applications in product development and in understanding behavior of ceramic materials. *Mr. Hummel*

504. Solid State Reactions in Ceramic Systems (2) Thermodynamic, kinetic, and structural study of reactions and of equilibrium in ceramic systems. Prerequisites: Chem. 451, 452. *Mr. Stubican*

505. Phase Transition in Solids (2) Phase transitions will be studied in detail with respect to the crystal structure, free energy, and physical properties.

506. Mechanical Properties of Ceramics (3) Theoretical consideration of internal stresses, dislocations and dislocation processes, and macro- and microstructural variables on the mechanical properties of ceramics. Prerequisite: Cer.Sc. 414. *Mr. Bradt*

507. Thermal Properties of Ceramic Materials (2-3) Heat capacity, heat of fusion, thermal conductivity, and thermal expansion in relation to macroscopic measurements and basic atomic concepts applied to ceramic materials. *Mr. Stubican*

508. Dielectric and Magnetic Properties of Ceramic Materials (2-3) Preparation and properties of ceramic semiconductors, dielectrics, and magnetic materials.

509. Composite Materials (3) Manufacturing processes, atomic and molecular background, and topological relationships of macro- and microstructure to the physical properties of composites. *Mr. Bradt*

510. Seminar in Glass Technology (1-2 per term) Current developments in glass technology and related fields. *Mr. Rindone*

511. The Constitution of Glass (2-3 per term) Historical and current concepts of the atomic structure of glass; relationship of structure to chemical and physical properties. *Mr. Rindone*

512. Selected Properties of the Vitreous State (2-3 per term) Measurement and interpretation of such properties as: radiation effects; viscoelasticity; electrical, mechanical, optical, and thermal properties. *Mr. Rindone*

515. Special Problems in Ceramic Science (1-6 per term) Advanced individual study on a problem in ceramics.

516. Selected Topics in Ceramic Science (1-3 per term) Intensive group study of special topics.

530. (Min. 530) Structure, Properties, and Occurrence of Clay Minerals (2-5) Structure analysis and identification of clay minerals; mineral transformation and behavior; occurrence, genesis, and petrography of fine-grained sediments. *Messrs. Brindley and Hsu*

Note: *Courses in the use of X-ray diffraction, electron microscopy, and the electron microprobe in ceramic science studies are listed under Materials Science.*

CHEMICAL ENGINEERING (CH E)

LEE C. EAGLETON, *Head of the Department*
160 Chemical Engineering Building West

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Braun, Fenske, Jones, Klaus, and McCormick; Associate Professors Daubert, Engel, Hersh, and Kabel.

Graduate Faculty, Associate Members: Assistant Professors Barton, Danner, and Evans.

Course offerings or research facilities are available in the following areas: phase equilibria, thermodynamics, kinetics, mass transfer, transport phenomena, unit operations, unit processes, nuclear chemical engineering, applied chemistry and petrochemistry, petroleum technology, rheology, and lubrication. The facilities for instruction and research in chemical engineering and petroleum chemistry include those of the Petroleum Refining Laboratory.

To be admitted, a student should be a graduate of an accredited major in chemical engineering or the equivalent. Graduates of other accredited engineering or physical science majors may be admitted but will be required to make up certain undergraduate deficiencies without graduate credit. Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

CHEMICAL ENGINEERING (CH E)

404.	CHEMICAL ENGINEERING ECONOMICS (3)	*Mr. Engel*
405.	THERMODYNAMICS FOR CHEMICAL ENGINEERS (3)	
406.	CHEMICAL ENGINEERING PROBLEMS (3)	*Messrs. Engel and Barton*
410.	CHEMICAL ENGINEERING PRINCIPLES (3)	*Messrs. Daubert and Evans*
411.	CHEMICAL ENGINEERING PRINCIPLES (3)	*Messrs. Daubert and Evans*
412.	CHEMICAL ENGINEERING PRINCIPLES (3)	*Messrs. Daubert and Evans*
415.	ANALYSIS AND MATHEMATICAL SIMULATION IN CHEMICAL ENGINEERING (3)	
420.	CRYOGENIC ENGINEERING (3)	*Mr. Danner*
422.	PETROLEUM PROCESSES AND PRODUCTS (2)	*Mr. Peiffer*
426.	INTRODUCTION TO TRANSPORT PHENOMENA (3)	*Mr. Kabel*
430.	NUCLEAR CHEMICAL ENGINEERING (3)	*Mr. Evans*
435.	CHEMICAL REACTION KINETICS (2)	*Mr. Kabel*
440.	CHEMICAL ENGINEERING MATERIALS (3)	*Mr. Engel*
445.	CHEMICAL ENGINEERING RESEARCH (1-5)	
450.	PROCESS DYNAMICS (3)	*Mr. Peiffer*
460.	CHEMICAL ENGINEERING (4)	*Mr. Barton*

500. SEMINAR IN CHEMICAL ENGINEERING (1) Required of all graduate students.

505. SPECIAL TOPICS IN CHEMICAL ENGINEERING (2-12) Intensive study in the various specialized fields of chemical engineering.

508. PRINCIPLES OF INDUSTRIAL ORGANIC CHEMISTRY (3) Principles and practices of modern conversion processes in the manufacture of organic chemicals. Prerequisites: Chem. 31, 452, Ch.E. 30.

509. HEAT TRANSFER APPLICATIONS (3) Advanced treatment of steady-state and transient conduction, convection, and radiation, with emphasis on numerical methods and design techniques. Prerequisite: an undergraduate course in heat transfer.

515. Distillation (3) Commercial distillation, equilibrium diagrams, vapor composition, stills and rectifying and stripping columns.

516. Methods of Process Design (3) Survey of mathematical techniques of chemical process design with emphasis on economic choice and optimal decision-making.

520. Extraction Processes (3) Equilibrium extraction data and phase contacting and settling related to equipment design.

521. Transport Phenomena (3) Momentum, heat, and mass transfer in boundary layers and turbulent fluids; ideal potential flow; unsteady state and coupled transport.

522. Special Topics in Transport Phenomena (3) Intensive group study and discussion of current problems and techniques in transport processes. Prerequisite: Ch.E. 521.

524. Chemical Engineering, Application of Thermodynamics (3) Elements of thermochemistry and thermodynamics of greatest importance in chemical engineering.

535. Chemical Reaction Engineering (3) Optimal design of batch and continuous chemical reactors and reactor batteries; effect of mixing on reactor operation. Prerequisite: Ch.E. 435.

CHEMISTRY (CHEM)

Thomas Wartik, *Head of the Department*
212 Whitmore Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Deno, Dixon, Fritz, Haas, Hisatsune, Jackman, Jordan, Lampe, Miller, Noll, Oakwood, Shamma, Skell, Steele, Wartik, and Zook; Associate Professors Allcock, Ascah, Baldwin, Benkovic, Bernheim, Hamilton, Hayes, Heicklen, Olofson, Richey, Rosenblatt, and Schempf.

Graduate Faculty, Associate Members: Assistant Professors Crawford, Gold, Long, Lotz, Lowe, Riehl, and Stanko.

Students may specialize in analytical, inorganic, organic, or physical chemistry. The general facilities are excellent, and the computer, cryogenic, petroleum, radiochemical, and spectroscopy laboratories provide unusual research opportunities. Distinguished visiting scholars conduct informal discussion each Thursday at a departmental colloquium. In addition, the Corn Products Lectures in Advanced Chemistry are presented each spring. These thirty lectures, by distinguished visiting scientists-in-residence, are devoted to in-depth descriptions of frontier investigations in chemistry.

For admission, at least integral calculus plus one year's work in general physics, organic chemistry, physical chemistry, and either analytical or inorganic chemistry is normally required. Students who present a 2.50 average in all undergraduate courses in chemistry, physics, and mathematics will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

Prior to scheduling their first term programs, new students will take examinations

in three of the four areas of analytical, inorganic, organic, and physical chemistry. The information obtained from these tests will assist both the student and his adviser in making up a program best suited to the student's needs. These examinations are normally given just prior to the regular registration period.

CHEMISTRY (CHEM)

400. Chemical Literature (1)
401. Seminar (1)
405. Nuclear and Radiochemistry (3)
410. Inorganic Chemistry (2)
411. Advanced Inorganic Chemistry (2)
412. Experimental Inorganic Chemistry (2)
423. Advanced Analytical Chemistry (3)
424. Advanced Analytical Laboratory (2)
426. Chemical Instrumentation (3-5)
431. Advanced Organic Chemistry Laboratory (3)
435. Advanced Organic Chemistry Laboratory (3)
439. Advanced Organic Chemistry (3)
448. Colloid Chemistry (3)
*451-452. Physical Chemistry (3 each)
453. Advanced Physical Chemistry (3)
454. Advanced Physical Chemistry (3)
455. Physical Chemistry of High Polymers (3)
*457-458. Experimental Physical Chemistry (1 each)
489. Introduction to Chemical Research (1-10)
493. Selected Topics in Chemistry for Teachers (3-9)

500. Seminar in Inorganic Chemistry (1 per term)

501. Seminar in Physical Chemistry (1 per term)

502. Seminar in Organic Chemistry (1 per term)

503. Seminar in Analytical Chemistry (1 per term)

516-517. Inorganic Chemistry (3 each) Systematic treatment of inorganic chemistry in terms of modern concepts.

518. Special Topics in Inorganic Chemistry (3 per term) Modern developments in specialized fields.

525. Analytical Processes (3) Theoretical foundations and contemporary developments.

526. Modern Instrumental Analysis (3)

527. Special Topics in Analytical Chemistry (2-12)

531. Special Topics in Organic Chemistry (3-12)

534. Chemical Applications of Quantum Theory (3) A development of Molecular Orbital Theory up to the level of present-day usage in organic and inorganic chemistry.

535-536. Organic Chemistry (3 each) Adapted to the needs of those doing research work in organic chemistry.

* Graduate credit not allowed for students majoring in chemistry or chemical engineering.

538. Organic Chemistry (3) Survey of organic chemistry arranged primarily for graduate students majoring in fields other than organic chemistry.

544. Chemical Thermodynamics (3) Development of thermodynamic theory with special reference to common physical changes and chemical reactions. Prerequisite: Chem. 452.

545. Statistical Thermodynamics (3) The calculation of thermodynamic properties from molecular and spectroscopic data. Prerequisites: Chem. 544, 565.

560. Topics in Physical Chemistry (2-6)

563. Chemical Kinetics (3) Theory and measurement of the rates of chemical reactions, molecular dynamics, and mechanisms of chemical reactions. Prerequisites: Chem. 544, 565.

565. Atomic and Molecular Structure (3) Introduction to modern theoretical chemistry, spectroscopy, and structure of atoms and molecules.

566. Quantum Chemistry (3) Theoretical calculations of electronic properties of atoms and molecules. Prerequisite: Chem. 565. Prerequisite or concurrent: Math. 555.

567. Quantum Chemistry (3) A continuation of Chem. 566, including problems and theories of electron correlation. Prerequisite: Chem. 566.

CHILD DEVELOPMENT AND FAMILY RELATIONSHIPS (CDFR)

Joseph H. Britton
In Charge of Graduate Programs in Child Development and Family Relationships
S-105E Human Development Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors Britton, Harms, Harris, Smith, and Taylor; Associate Professors Bortner, Broderick, de Lissovoy, and Urban.

Graduate Faculty, Associate Members: Assistant Professors Peters and Stein.

Programs emphasize interdisciplinary study of growth, development, and aging, and interpersonal processes in the family, the neighborhood, and the larger community. The perspective encompasses the human life span, socialization processes, and the individual's roles in marriage, parenthood, and other social institutions in various cultural settings. The faculty includes persons in the psychological and social sciences particularly committed to research and application in these interdisciplinary fields.

Students are expected to emphasize one area of study or professional orientation. They may prepare for positions in teaching and research in colleges, secondary and elementary schools, and in nursery schools; for work as human development specialists with children, parents, or other adults; and for service in community agencies.

The department operates preschool and infant laboratories as part of the teaching and research program. Each unit has observational facilites, and there are adjoining rooms for study of individual and group behavior of children and of adults. Additional resources, such as the Psychology Clinic, the Special Education Center for Children, the Speech and Hearing Clinic, and the Computation Center, are available in other parts of the University.

The entering student should have at least 6 credits in the biological and physical

sciences, 12 in the social sciences (including a basic course in both sociology and psychology), and 6 in human development and family relationships. Students not meeting these requirements may be admitted with limited deficiencies to be made up concurrently with their graduate studies.

Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

INDIVIDUAL AND FAMILY STUDIES (I F S)

410. Communities and Families (3)
413. Dysfunctions in the Developmental Process (3)
414. Resolving Individual and Family Problems (3)
415. Child Development and Family Relationships for Secondary Schools (3)
418. Family Relationships (3)
420. Problems in the Analysis of Individual Development (3-9)
427. Conceptions in Development (3)
428. Infant Development (3)
429. Advanced Child Development (3)
430. Practicum in Preschool Groups (1-6)
432. Developmental Problems of Normal Children (3)
435. Developmental Transition to Adulthood (3)
441. Organization Planning for Preschool Programs (3)
445. (Psy. 445) Development Throughout Adulthood (3)
481. Developmental Programming for Preschool Children (3)

500. Nonthesis Research (1-9)

508. Parental Education (3) Discussion and use of methods, experiences, and programs which can be used effectively to help parents in dealing with problems of parent-child relationships.

515. The Teaching of Child Development and Family Relationships (3) Methods of selection and presentation of subject matter basic to understanding the development of children.

520. Infancy (3) Infant development, with emphasis on factors influencing development and the relationships of early experience to later behavior. Prerequisites: 6 graduate credits in child development and family relationships, psychology, or biological sciences and 3 credits in statistics.

529. (Psy. 529) Seminar in Child Development (1-6) Readings and reports on recent findings in child development. Prerequisites: 6 graduate credits in child development, child psychology, or educational psychology, plus 3 in statistics.

530. Problems in Child Development and Family Relationships (1-9) Problems involving individual research in library, laboratory, or field projects.

536. (Psy. 536) Research Methods in Child Development (3) Prerequisites: 6 credits in child development and a course in statistics.

545. The Family in Its Community (3) Cultural influences on family relationships; how the family orients its members to community living and group participation.

546. Seminar in Family Relationships (1-9) Reading, reports, and discussion of recent research in relationship aspects of family living; particular attention to studies of roles, crises, and adjustments within the family setting.

548. Survey of Research on Sexual Behavior (3) Survey and evaluation of the contributions to the studies of sex by H. Ellis, Freud, Malinowski, Terman, Kinsey, and others. Prerequisites: 12 credits at the 400 and 500 level in child development and family relationships, psychology, sociology, or anthropology; 3 credits in statistics.

549. (Psy. 549) Theories of Child Development (2-3) Historical background of the major theories concerning child development and behavior and their application.

550. Perspectives in Child Development (3) Analysis of developmental studies since 1920. Examination of childhood in philosophy, education, literature, and art prior to 1920. Prerequisites: 6 graduate credits in psychology or child development and family relationships and 3 credits in statistics.

579. Seminar in Adult Development and Aging (1-9) A seminar dealing with specific topics concerning adult development and aging. Prerequisites: I.F.S. 445 and statistics.

CIVIL ENGINEERING (C E)

Benjamin A. Whisler, *Head of the Department*
212 Sackett Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty, Senior Members: Professors Brielmaier, Gotolski, Hurd, Kountz, Larson, Nesbitt, Perez, and Whisler; Associate Professors Barnoff, Blue, and Reich; Assistant Professor Cady.

Graduate Faculty, Associate Members: Associate Professors McDonnell and Weeden; Assistant Professors Davinroy, Mozingo, Taylor, Unz, and West.

Students may specialize in structures, hydraulics, hydrology, transportation engineering, traffic engineering, materials, soils, and sanitary engineering, or combinations of these. Relevant courses are offered both by the Department of Civil Engineering and by other departments of the University.

Students who present a 2.50 junior-senior average and are graduates in civil (or sanitary) engineering from an accredited college of engineering will be acceptable to the department subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

See also Sanitary Engineering.

CIVIL ENGINEERING (C E)

400. Seminar (1-3)
401. Civil Engineering Projects (2-12)
421. Highway Engineering (3)
422. Transportation Engineering (3)
423. Traffic Characteristics and Measurements (3)
424. Civil Engineering Materials (3)
431. Civil Engineering Construction (3)
444. Engineering Soil Characteristics (3)
445. Soil Exploration and Analysis (3)
446. Advanced Soil Mechanics (3)
447. Structural Analysis by Matrix Methods (3)

448. Advanced Structural Design (3)
451. Advanced Hydrology (3)
452. Water Resources and Computations (4)
462. Open Channel Hydraulics (3)
465. River and Waterways Engineering (3)
471. Environmental Sanitation (3)
472. Water Pollution Control (3)

500. Seminar in Civil Engineering (1-6) Reports on researches and special topics. Course may be continued in subsequent terms.

501. Civil Engineering Projects (3-10) Investigation or design projects in structures, transportation, hydraulics, or civil engineering materials.

519. Traffic Administration and Finance (2) Organization and administration of traffic engineering at various levels of government; leaders in the highway transportation field are guest lecturers.

520. Pavement Design (3) Fundamental principles; properties of pavement components; design tests; design of flexible pavements; design of rigid pavements; pavement evaluation and strengthening.

521. Techniques of Transportation Analysis (2-4) Transportation functions, travel patterns, basic analytical methods in the planning content.

522. Highway Operations (2) Theory and application of traffic controls, including functional operations of traffic signals, systems, and networks; the design of highway lighting.

523. Urban Transportation Planning (2-4) The problem in historical perspective, current content, costing procedures, public policy, the planning process.

524. Advanced Problems in Civil Engineering Materials (2-6) Study, in the literature and by laboratory investigation, of selected topics on field-controlled civil engineering materials. Prerequisite: C.E. 424.

525. Airport Planning and Design (3) Aircraft characteristics; aeronautical demand; site selection; airport configuration; capacity analysis; design of landing and terminal areas.

526. Design of Transportation Facilities (3) Basic principles and engineering design of truck terminals, railroad yards and terminals, bus terminals, and parking facilities.

527. Theory of Traffic Flow (3) Phenomenon of vehicular traffic flow; flow density relationships; spacing; gap counting; delays; problems involving interrupted flow; multiflow routes.

528. Queuing Models in Transportation (3) Arrival patterns; the service mechanism; queue discipline; delays; multiple queues; problems involving various combinations of queues and service facilities.

529. Highway Geometric Design (3) Principles of road and parking terminal design with emphasis on operations; highway planning related to alternate solutions of design problems. Prerequisites: C.E. 423, 522.

533. Ultimate and Plastic Design Methods (3) Plastic design of steel structures. Limit design of concrete structures. Ultimate theories applied to plate and slab problems.

537. Matrix Method of Structural Analysis (3) Analysis of structures using

advanced matrix techniques, transformation of matrices, energy concepts, iterative solutions, applications to linear and nonlinear structures. Prerequisite: C.E. 447.

539. Approximate Methods of Structural Analysis (3) Newmark's method, finite difference method, and finite element method applied to problems in structural and soil engineering.

540. Advanced Structural Analysis I (3) Analysis of continuous beams, frames on elastic supports, grids, and arches under various loading conditions. Influence lines and deformations.

541. Advanced Structural Analysis II (3) Redundant, continuous, hybrid trusses, influence lines; secondary stresses; framed arches; suspension systems, selection of bridge type; space framing.

542. Applied Soil Mechanics (2-5) Soil classification by type of clay minerals and profile development; aerial photographic interpretation of soils and applications to site selection for dams, highways, and airports.

544. Advanced Design of Concrete Structures (3) Concrete working stress, ultimate strength, limit design; test behavior of beams, slabs, columns; simple and continuous prestressed concrete members.

545. Advanced Structural Design (2-4) Steel, aluminum members; flexible connections; composite, hybrid, prestressed beams; tension-field beams; buckling; plastic analysis, design; test data; timber design. Prerequisite: C.E. 41.

546. Thin Concrete Structures (3) Design of thin concrete structures including slabs, folded plates, and shells.

548. Structural Design for Dynamic Loads (3) Dynamic behavior of structural systems of one and more degrees of freedom; earthquake, blast-resistant analysis, and design of structures.

549. Long Span Structures (3) Analysis and design of suspension bridges, cable roofs, and arch-type structures.

550. Engineering Construction Management (2-4) Management fundamentals for construction contracting; organization, project planning, scheduling and control, bonding and insurance, labor legislation and regulation, cost and control. Prerequisite: C.E. 431.

551. Hydrologic Investigations (2-8) Application of hydrologic principles and techniques to a specific project.

552. Hydrologic Processes and Cybernetics (3) Application of cybernetic concepts in electronic computer simulation of the hydrologic process-components: infiltration, precipitation, evapotranspiration, and overland flow. Prerequisite: C.E. 51 or 452.

553. Planning Multipurpose Hydrologic Systems (3) Study of multipurpose hydrologic schemes within a social, economical, and political framework. Prerequisite: C.E. 451 or 452.

554. Urban Hydrology (3) Several hydrograph methods. Design storm and IUH application; airport drainage; flood planes; impact of urbanization upon groundwater and sediment. Prerequisite: C.E. 451 or 452.

560. Dimensional Analysis and Theory of Models (3) Principles of dimensional analysis and similitude with engineering applications.

564. Hydraulic Engineering Design (2-8) Design and analysis of selected units of a typical hydraulic engineering project.

565. Transportation of Solids by Fluids (2-5) Fundamentals of the flow of solids in open and closed conduits; e.g., suspended load and bed load in rivers, slurries and pulp stocks in pipes.

571. Water Treatment Theory (3) Theory of modern methods of conditioning water for municipal and industrial use. Prerequisite: C.E. 472.

572. Waste Treatment Theory (3) Theory of modern methods of waste treatment. Prerequisite: C.E. 472.

573. Advanced Problems in Sanitary Engineering (3-10) Investigations, analyses, and reports on current topics in sanitary engineering.

574. Analytical Evaluations in Sanitary Engineering (3) Experiments illustrating current chemical and biochemical methods of water and waste treatment and analytical methods used in research and control.

575. Advanced Industrial Waste Treatment (3) Techniques of industrial waste treatment; attendant stream pollution and stream self-purification factors. Prerequisite: C.E. 472 or 572.

576. Water Treatment Plant Design (1-6) Design of works for treatment of water for municipal and industrial use. Prerequisite: C.E. 71.

577. Sewage Treatment Plant Design (1-6) Design of works for treatment of sewage or industrial wastes. Prerequisite: C.E. 71.

580. Stream and Estuarine Analysis (3) Quantitative assessment of advection, reaction, and dispersion processes in polluted waters; reaeration theory; eutrophic systems; analog simulation. Prerequisite: C.E. 472.

CLASSICS (CLASS)

Anthony J. Podlecki, *Head of the Department*
103 Ihlseng Building

Degree Conferred: M.A.

Graduate Faculty, Senior Members: Associate Professors Carrubba and Podlecki.

Programs leading to the master's degree in this field offer opportunities for specialization in either Latin or Greek, or a combination of both. The minimum requirement for admission to either program will normally be 18 undergraduate credits in either language. Provision is made, however, for admission with limited deficiencies. Candidates may either submit a thesis or schedule 6 additional credits in 500-level courses in the major field.

Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

GREEK (GREEK)

420. The Greek Historians (3)
421. Greek Tragedy (3)
422. Greek Comedy (3)
425. Homer (3)
430. The Greek Philosophers (3-9)

450. Topics in Greek Literature (3-6)
451. History of the Greek Language (3)
498. Studies in Greek Literature (1-6)

502. Greek and Latin Epigraphy (3) Study of the techniques of epigraphical research; the value of inscriptions for Greek and Roman history and private antiquities.

507. Problems in Greek Archaeology (3-9)

509. Greek Seminar (3-9)

517. Greek Research (1-6) Prosecution of an assigned problem under the guidance of a member of the department.

LATIN (LATIN)

420. The Latin Historians (3)
425. Latin Elegy (3)
426. Roman Comedy (3)
427. Vergil (3)
428. Lucretius (3)
430. Medieval Latin (3-6)
431. Roman Satire (3)
432. Roman Rhetorical and Literary Theory (3)
436. The Teaching of Latin (3)
437. Latin Prose Composition (3-6)
460. Topics in Latin Literature (3-6)
461. History of the Latin Language (3)
498. Studies in Latin Literature (1-6)

500. Latin Literature (3-9) Readings in the major forms of Latin literature; content varies, course may be repeated.

501. Roman Religion and Philosophy (3) Development of religious concepts at Rome from primitive Italic origins to the advanced forms that culminated in Roman Stoicism. Prerequisites: two 400-level courses in Latin.

510. Latin Seminar (3-6)

518. Latin Research (1-6) Prosecution of an assigned problem under the guidance of a member of the department.

*CLASSICS (CLASS)

401. The Classics and Archaeology (3)
405. Greek and Roman Mythology (3)
406. Emergence and Development of Classical Poetic Genres (3)
408. Greek Religion and Modern Man (3)
410. Classical Epic (3)
411. Classical Drama (3)
412. Classical Historians (3)
413. Readings in Classical Literature (3)

500. Introduction to Classical Scholarship (1-6) Lectures on the methods and materials of classical scholarship. To be scheduled by graduate students in their first term, and as necessary thereafter.

* The readings are in English; knowledge of Greek and Latin is not required.

CLOTHING AND TEXTILES (CL TX)

(See Man-Environment Relations)

COMPARATIVE LITERATURE (C LIT)

PHILIP A. SHELLEY
In Charge of Graduate Programs in Comparative Literature
203 Schwab Auditorium

Degrees Conferred: Ph.D., M.A.

Graduate Faculty, Senior Members: Professors Bayard, Hyslop, Lewis, Shelley, Townsend, and Weintraub; Associate Professors Wellwarth and West; Assistant Professor Lima.

Graduate Faculty, Associate Member: Associate Professor Timpe.

Programs of study in international literary and cultural relations are arranged in accordance with individual students' interests through a meaningful selection of courses both in comparative literature and in the several national literatures. Topics appropriate to such programs include the following: the currency, reception, and influence of writers and works in countries other than those of their origin; the origin, transmission, and evolution of international literary movements; the characterisics and relations of genres, themes, and motifs; folk literature and folklore; criticism; aesthetics; intermediaries; and relationships between literature and other disciplines.

In addition to the general requirements for graduate degrees, the following special ones apply:

Master of Arts: courses in comparative literature (9 credits) and two national literatures (9 and 6 credits), knowledge of the language of each of the two literatures, a written examination, and a thesis (6 credits).

Doctor of Philosophy: courses in comparative literature (18 credits) and three national literatures (24, 12, and 12 credits), and a knowledge of the language of each of the three literatures. Courses taken for the master's degree may be applied in satisfaction of the doctor's degree.

Admission requirements include: an appropriate degree in literature or a related discipline, together with a good knowledge of at least one foreign language for candidates for the master's degree, and of at least two for candidates for the doctor's degree. Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

COMPARATIVE LITERATURE (C LIT)

401. WESTERN LITERATURE I (3)
402. WESTERN LITERATURE II (3)
403. WESTERN LITERATURE III (3)
408. HEROIC-AGE EPICS AND SAGAS (3) *Mr. Bayard*
443. (Ger. 443) LITERARY RELATIONS OF GERMANY WITH ENGLAND AND AMERICA (3-9) *Mr. Shelley*
470. OLD MASTERS OF THE MODERN NOVEL (3)
480. INTRODUCTION TO FOLKLORE (3) *Mr. Bayard*
486. TRAGEDY (3) *Mr. Wellwarth*
487. COMEDY (3) *Mr. Wellwarth*

488. (Engl. 488) Modern Continental Drama (3)
Messrs. Weintraub and Wellwarth

498. Special Subjects and Problems of Comparative Literature (3)

500. Seminar in Comparative Literature (3-6)

501. Comparative Method in Literary Studies (3)

508. Norse and Gaelic Sagas (3) Medieval Irish and Scandinavian prose tales surveyed and compared with respect to backgrounds, development, themes, and characteristics. *Mr. Bayard*

570. Forces in Contemporary European Literature (3) The intellectual currents that have influenced European writers of the mid-twentieth century: Beckett, Böll, Robbe-Grillet, and others. *Mr. West*

588. Twentieth Century Drama (3) Translation and comparative analysis of previously untranslated plays. Prerequisite: fluent reading knowledge of a foreign language. *Mr. Wellwarth*

593. (Engl. 593) Anglo-American Folk Song (3) Survey of relevant literary and ethnological scholarship and field work, European and American, from the early 16th century to the present. *Mr. Bayard*

COMPUTER SCIENCE (CMPSC)

Preston C. Hammer, *Head of the Department*
426 McAllister Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Gotterer and Hammer; Associate Professors de Maine, Laird, and Singletary.

Graduate Faculty, Associate Members: Associate Professors Barnes, Day, and McCammon; Assistant Professors Deutsch, Honkanen, Hsu, Johnson, Jones, Squires, and Yntema.

The department offers courses and is prepared to direct research in a variety of subfields of computer science, including foundations of computer science, languages and programming systems, numerical analysis, nonnumeric procedures, and heuristic methods. The Computation Center has modern digital equipment and systems available for research and instruction.

Admission to the M.S. program without deficiency requires the equivalent of Cmp.Sc. 401 and at least three of the five following: (1) Math. 441 or 481, (2) Cmp.Sc. 410, (3) Math. 453, (4) Math. 454, (5) Math. 428 or E.E. 471. The remainder of these five must be completed for the M.S. or Ph.D.

The M.S. candidate must satisfactorily complete (a) Cmp.Sc. 510 or 511 and (b) Cmp.Sc. 530 or 540, in addition to the other requirements of the Graduate School. The no-thesis option is available for the M.S. degree.

Admission as a candidate for the Ph.D. normally requires completion of course requirements for the M.S. or an equivalent background.

The Ph.D. candidate must pass three written examinations: two in subfields of computer science and one in another subfield of computer science, a subfield of mathematics, or approved other area.

Students who present a 2.75 junior-senior average will be acceptable to the depart-

ment provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

COMPUTER SCIENCE (CMPSC)

401. Principles of Programming with Physical Science Applications (3)
402. Principles of Programming with Social and Biological Science Applications (3)
403. Principles of Programming with Business Applications (3)
404. Information Structures (3)
410. Introduction to Computer Systems (3)
411. Systems Organization and Programming (3)
420. The Structure of Programming Languages (3)
430. Combinatorics and Graph Theory (3)
450. Information Theory and Error-Correcting Codes (3)
453. (Math. 453) Numerical Computations (3)
454. (Math. 454) Matrix Computations (3)
460. Logic and Computability (3)
485. Introduction to Information and Language Structures (4)
490. Special Topics in Computer Science (1-9)
491. Computer Projects (3)

500. Theory of Automata (3) The structure of finite automata and sequential machines including characterization theorems, minimization problems, state identification experiments and decomposition theory. Prerequisites: Cmp.Sc. 401, 402, or 403; 3 credits in logic at the 400 level.

501. Algebraic Theory of Automata (3) Prerequisite: Cmp.Sc. 500.

510. Structure of Artificial Languages (3) Structure of problem-oriented languages; syntactical description, algorithms for translation, list structures, string manipulation, formula manipulation, relation to linguistics. Prerequisites: 3 credits in logic or logical design at the 400 level; Cmp.Sc. 420 or 485.

511. Systems Programming (3) Interpretive systems; assemblers, loaders, compilers, library monitor systems; input-output scheduling; executive programs, job scheduling; multi-access systems, multiprogramming, multiprocessing. Prerequisite: Cmp.Sc. 404, 420, or 485.

530. Nonarithmetic Programming (3) Combinatorial problems, learning mechanisms, heuristic programs, and pattern recognition. Prerequisite: Cmp.Sc. 420 or 485.

535. Theory of Graphs and Networks (3) Theory and applications of graphs including structure of graphs, network analysis and algorithms for computer solution of graph-theoretic problems. Prerequisite: Cmp.Sc. 430.

540. Information Processing Systems (3) Data structures and data processing; information retrieval systems. Prerequisite: Cmp.Sc. 404 or 485.

545. Information Retrieval (3) This course deals with input-output, design implementation, evaluation, global memories and comparison of information retrieval systems. Prerequisite: Cmp.Sc. 540.

550. Algebraic Coding Theory (3) Polynomial rings, Galois fields; cyclic codes; structure and properties, burst error correction; BCH codes; decoding techniques, recurrent codes, residue codes. Prerequisite: Cmp.Sc. 450.

560. Combinatorial Systems (3) The relationships among various forms of combinatorial systems including Turing machines, Post normal systems, Thue systems and recursive functions. Prerequisite: Cmp.Sc. 460.

568-569. Theory of Formal Languages and Automata (3 each) Generation and recognition of formal language, grammar, Chomsky's hierarchy of languages, closure properties, characterization by automata, algebraic properties, complexity classification. Prerequisite: Cmp.Sc. 500.

590. Seminar in Computer Science (1-3) Topics from current research.

591. Special Topics in Computer Science (2-6)

592. Special Topics in Foundations (2-6)

593. Special Topics in Languages and Systems (2-6)

594. Special Topics in Nonnumerical and Self-improving Systems (2-6)

COUNSELOR EDUCATION (CN ED)

Edwin L. Herr
In Charge of Graduate Programs in Counselor Education
110C Education Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors Herr, Hudson, Hylbert, and Wellington.
Graduate Faculty, Associate Members: Associate Professors Britton and Kelz.

Professional preparation is offered at the master's level for school counselors (elementary and secondary), college counselors or persons entering college student personnel services, and rehabilitation counselors. Doctoral programs prepare candidates for positions of responsibility and leadership in these same areas. Doctoral candidates must have a minimum of one year's work experience in their field.

All candidates for graduate degrees in counselor education must present for admission at least 27 undergraduate credits and a grade point average of 3.00 in economics, education, psychology, sociology, and physiology or anatomy with some credits in at least three of these areas. Students who present a 2.50 junior-senior average will be acceptable to the department provided they have the appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests. Doctoral candidates should present a 3.33 average in all graduate study completed and a satisfactory score on the Miller Analogies Test.

All candidates are expected to exhibit, in addition to academic competence, effectiveness in interpersonal relations and in both written and oral communication. They must also evidence support of professional counseling activities and organizations.

A candidate for either a Ph.D. or a D.Ed. must earn at least 30 credits in six or fewer consecutive terms in residence after completing the master's degree, preferably at the thesis planning and writing stage.

COUNSELOR EDUCATION (CN ED)

403. Foundations of Guidance and Counseling Processes (3)
404. Group Procedures in Guidance and Counseling (3)

408. Introduction to Vocational Rehabilitation (3)
409. Medical Information for Counselors (3)
410. Rehabilitation of the Mentally Ill (3)
412. Rehabilitation Facilities and Services of Pennsylvania (3)
413. Rehabilitation Case Recording and Management (3)

501. Counseling: Theory and Method (3) Theory and methods of counseling individuals whose problems of choice, decision, and adjustment fall within the normal range. Prerequisite: Cn.Ed. 403 or 408 or 551.

503. Guidance Services in Elementary Education (3) Guidance services to elementary school students; guidance opportunities for elementary teachers and principals. Prerequisite: Cn.Ed. 403.

504. Guidance Services in Secondary Education (3) Nature and scope of guidance in secondary schools—services, models, and strategies; the counselor as an agent of change. Prerequisite: Cn.Ed. 403.

505. Foundations of Counseling Information (3) Accelerating change in economic, psychological, social, educational influences upon counselees. Utilization of information systems in effecting counselee change. Prerequisite: Cn.Ed. 403 or 408 or 504 or 551.

506. Individual Analysis and Counseling Procedures (3) Collection and use of data basic to the counselor's understanding of individuals; the counseling interview and techniques other than testing. Prerequisites: Ed.Psy. 451 and Cn.Ed. 408 or 503 or 504.

507. Counseling Practicum (1-6) Practice in the application of guidance principles and methods to cases counseled under supervision; case conferences; seminar in guidance techniques. Prerequisite: Cn.Ed. 506.

508. Organization and Administration of Guidance Programs (3) Principles, organization, personnel, functions, integration with school programs, evaluation. Prerequisite: Cn.Ed. 506.

509. Contributions of Professional Personnel to Vocational Rehabilitation (3) Contributions of medical, social, psychological, and other specialists through the team approach; professional ethics, medical problems. Prerequisites: Cn.Ed. 403, 408.

511. Supervised Practicum in Rehabilitation Counseling (1-6) Application of principles and techniques of rehabilitation counseling to cases involving handicapped individuals. Prerequisites: Cn.Ed. 403, 408.

512. Professional Experience in Rehabilitation Counseling (1-6) Supervised internship with responsibility for a regular case load. Prerequisites: Cn.Ed. 403, 408.

513. Supervision of Counselors (3-9) Practical experience in supervising and evaluating work of counselors. Prerequisite: Cn.Ed. 507.

551. Student Personnel Services (2-3) Student personnel services in higher education; organization of student advisory programs; use of personnel data; co-curricular activities; student welfare.

553. Student Personnel Services Programming (2-3) Formulation of policies as guides to the student personnel service programs; integration of program elements; research; current problems and trends. Prerequisites: Cn.Ed. 551, Hi.Ed. 545.

591. Seminar in Counseling: History and Trends (1) Discussion of the history of guidance and counseling, emphasizing how the past has shaped the present and protends the future. Prerequisite: 9 credits in counselor education.

592. Seminar in Counseling: Legal and Ethical Concerns (1-2) Study and discussion of legal, ethical, and professional concerns of counselors; privileged communication, data banks, and privacy invasion. Prerequisite: 9 credits in counselor education.

596. Seminar in Counseling, Guidance, and Rehabilitation (1-9) Conferences and discussions designed to meet the need for special study of particular topics in counseling, guidance, and rehabilitation. Prerequisite: 9 credits in counselor education.

597. Evaluation of Projects in School Guidance (2-6) Implementation and evaluation of program development projects in cooperation with state or local guidance programs. Prerequisite: 15 credits in counselor education.

DAIRY SCIENCE (D SC)

Donald V. Josephson, *Head of the Department*
105 Borland Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Almquist, Flipse, Josephson, Keeney, Kesler, Patton, and Watrous; Associate Professors Amann and McCarthy.

Graduate Faculty, Associate Members: Associate Professors Cloninger and Thoele.

Students may specialize in dairy products manufacture, chemistry of milk and dairy products, lipid metabolism, dairy cattle nutrition, dairy cattle genetics, dairy cattle management, and physiology of reproduction. The minor program is generally taken in biochemistry, microbiology, physiology, or agricultural economics.

Prerequisite to graduate work is the completion of an undergraduate major in animal industry, animal science, dairy science, food technology, or a related area. The undergraduate program must include college algebra and general physics. Students may be admitted with limited deficiency but are required to make up undergraduate deficiency work without degree credit.

Students who present a 2.70 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

DAIRY SCIENCE (D SC)

405. Dairy Cattle Management (3) *Mr. Cloninger*
418. Dairy Survey (1) *Mr. Shellenberger*
427. Milk Secretion (3) *Mr. Kesler*
428. Dairy Production Problems (1-6)
431. Physiology of Reproduction in Farm Animals (3) *Messrs. Almquist and Amann*

507. Dairy Cattle Management (1-6) *Mr. Kesler and Staff*

508. Dairy Seminar (1-6) Preparation and presentation of a paper on an assigned subject.

511. Dairy Cattle Nutrition (1-6) Nutritional requirements of dairy cattle. Prerequisite: A.Ntr. 401. *Mr. Kesler*

512. Advanced Studies in Milk Secretion (1-6) Physiology of milk secretion. Prerequisite: D.Sc. 427. *Mr. Kesler*

513. Dairy Cattle Breeding (1-6) Interpretation and application of current knowledge in genetics to dairy cattle breeding and selection. Prerequisites: An.Sc. 322, Biol. 422, 3 credits in statistics. *Mr. Thoele*

515. Advanced Physiology of Reproduction in Farm Animals (1-6) *Mr. Almquist*

516. Artificial Breeding of Farm Animals (1-6) Prerequisite: D.Sc. 431. *Mr. Almquist*

517. Dairy Science Literature (1-6) Review and reporting of dairy literature. *Mr. Josephson and Staff*

521. Dairy Radiophysiology (3) Metabolism and physiology of radioactive compounds; their use as tracers in animal physiology and the effects of radiation on metabolic processes. Prerequisite: Chem. 405. *Mr. McCarthy*

Note: *See Animal Science under "Other Elective Graduate Courses." Also see Food Science.*

EARTH SCIENCES (EARTH)

E. Willard Miller
Chairman of the Committee on Earth Sciences
101 Mineral Sciences Building

Degree Conferred: M.Ed.

This program is designed to meet the needs of science teachers in secondary schools. The fields of study are astronomy, geography, geology, meteorology, and mineralogy.

The program prepares candidates to teach at least one field of the earth sciences, familiarizes them with at least two additional earth science subjects, and at the same time enables them to increase their competence in the physical sciences, the biological sciences, and mathematics.

The student selects one of the earth sciences as an area of concentration, takes at least 12 credits in it, and is required to write a term paper in that area. An additional 12 credits must be taken in at least two other fields of earth sciences, or in two earth science fields plus two courses selected from the biological sciences, chemistry, mathematics, or physics. Furthermore, 6 credits in educational foundations are required as a minor.

Students who present a 2.50 junior-senior average, and have 18 credits in education and related psychology, will be accepted to the Earth Science major provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

The following courses offered by the various departments are appropriate for students majoring in earth and space science: Astro. 430; Geog. 490, 491; Geol. 400, 401, 402; Gphys. 400; Meteo. 400, 401, 402, 403, 404; Min. 402.

ECONOMICS (ECON)

GRANT N. FARR, *Head of the Department*
326 Boucke Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty, Senior Members: Professors Budd, Coppock, Farr, Kaufman, Klein, Levine, Mason, Newman, Prybyla, Reede, Robinson, Rozen, and Stout; Associate Professor Myers.

Graduate Faculty, Associate Members: Associate Professors Herendeen, Riew, Sauerlender, and Stromsdorfer; Assistant Professors Feller, Fox, and Hu.

Opportunities are available for concentration in the following fields: economic analysis, economic doctrines, economic development of developed areas, economic development of underdeveloped areas, economic fluctuations, income distribution, industrial organization, international economics, comparative economic systems, labor economics, money and banking, public finance, quantitative economics, statistics, and regional economics.

The department may waive the requirement of a thesis for M.A. candidates.

To enter graduate work in economics a student should have completed 6 credits in economic principles, 9 in the social sciences, and either 3 in statistics or 6 in mathematics. All applicants must take the Graduate Record Examination in advanced economics and general aptitude.

Students who present a 2.50 junior-senior average and a 3.00 in courses in economics will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

ECONOMICS (ECON)

400. HISTORY OF ECONOMIC THOUGHT I (3)
401. HISTORY OF ECONOMIC THOUGHT II (3)
404. CURRENT ECONOMIC ISSUES (3)
405. ADVANCED ECONOMIC ANALYSIS (3)
412. ECONOMICS OF COLLECTIVE BARGAINING (3)
413. COMPARATIVE LABOR MOVEMENTS (3)
414. (L.M.R. 414) THEORIES OF THE LABOR MOVEMENT (3)
415. SOCIAL INSURANCE (3)
418. ECONOMICS OF WAGES AND EMPLOYMENT (3)
419. CASE STUDIES IN LABOR-MANAGEMENT RELATIONS (3)
423. STATE AND LOCAL TAXATION (3)
427. (Ed.Adm. 427) ECONOMICS OF EDUCATION (3)
429. ADVANCED PUBLIC FINANCE (3)
433. INTERNATIONAL MONETARY ECONOMICS (3)
442. MONOPOLY, COMPETITION, AND THEIR REGULATION (3)
450. THE BUSINESS CYCLE (3)
451. MONETARY THEORY AND POLICY (3)
452. THE MONEY MARKETS (3)
461. ECONOMIC GROWTH: UNDERDEVELOPED AREAS (3)
462. ECONOMIC GROWTH: THEORIES OF UNITED STATES DEVELOPMENT (3)
480. MATHEMATICAL ECONOMICS (3)
490. INTRODUCTION TO ECONOMETRICS (3)
491. ANALYSIS OF LINEAR ECONOMIC MODELS (3)
498. SELECTED TOPICS IN ECONOMICS (3)
499. FOREIGN STUDY IN ECONOMICS (2-6)

500. Economic Seminar (3-6)

502. Microeconomic Analysis (3) Economic behavior under pure and imperfect competition; price and output determination in product markets; prices and employment in factor markets.

503. Macroeconomic Analysis (3) National income accounts; determination of income, employment, interest rates, and the price level; stabilization policy.

506. Problems in Economics (3-6) Planned individual projects involving library, laboratory, or field work.

507. International Trade (3) A survey of international trade theory including modern developments of pure theory, and of international trade policy.

508. Current Monetary Theory and Policy (3) Post-Keynesian reformulation of quantity and Keynesian theories of money; liquidity and general equilibrium approaches; current issues in theory and policy.

510. Econometrics (3-6) Statistical estimation in mathematically formulated economic relationships.

512. Wage Determination (3) Development of wage and employment theory; structure of labor markets; impact of unions on income distribution, price level, and employment.

513. Development of Economic Doctrines (3-6)

515. Economics of the Labor Market (3) Theory and problems of labor-management relations; selected problems of the labor market with reference to current research and developments.

516. Economics of Human Resources (3) Analysis of changes in human resource supply and demand; factors affecting these changes; current human resource policies.

517. International Finance (3) Problems of international liquidity; balance of payments adjustment; international financial institutions and selected policy problems.

518. Development of Monetary Theory (3) Classical and neoclassical quantity theories of money and contemporary criticism; Keynesian monetary theory and its critics.

521. Advanced Microeconomic Theory (3-6) Theory of consumer behavior; theory of the firm; price determination in product and factor markets; introduction to welfare economics.

522. Advanced Macroeconomic Theory (3-6) Measurement of income; theories of consumption, investment, and money holdings; static determination of income and employment; introduction to dynamic analysis.

524. Income Distribution (3) Measurement of inequality; ethical issues in income redistribution; measurement and determination of distributive shares; problem of poverty.

525. Economics of Technological Change (3) Theoretical and empirical analysis of invention and innovation and their effects on productivity, employment, and market structure.

528. Advanced Economic Theory: Selected Topics (3) Treatment of topics in economic theory to meet needs of advanced students seeking intensive work in selected areas.

529. Public Finance (3) Contemporary problems in public finance; instruments of fiscal policy in the achievement of full employment, price stability, and economic development.

530. Regional Microeconomics (3) Theoretical and empirical analysis of industrial location as determined by costs, markets, and agglomeration effects.

531. Regional Macroeconomics (3) Aggregate regional trade flows; sources of regional economic data; techniques for measuring regional economic activity; long-run regional growth.

543. Industrial Organization and Public Policy (3) The structure of American industry; performance and behavior; public policies toward business.

550. Economic Fluctuations (3) Analysis of the various theories of economic fluctuations; their methodological premises.

551. Stabilization Policy (3) Description and analysis of the alternatives and issues in stabilization policy.

560. Seminar in Economic Growth: Underdeveloped Areas (3-6) Resources and institutions; quantitative measures; theories of economic growth in developing areas; developmental policies.

561. Seminar in Economic Growth: Developed Areas (3-6) Growth models; strategic factors in growth; quantification problems; public policy.

571. Comparative Economic Systems (3) Comparative analysis of alternative resource allocation principles; growth and performance of different economic systems; problems of decision-making and control.

572. Soviet and Other Centrally Planned Economics (3) Principles, structure, and performance of centrally planned economies with special emphasis on the Soviet Union.

580. Mathematical Economics (3-9) Mathematical development of static and dynamic economic models: partial and general equilibrium analysis; growth dynamics; mathematical programming. Prerequisite: Econ. 480.

595. Seminar in Econometric Theory (3-6) Advanced study in the theories and problems relevant to the application of statistical methods to economics. Prerequisites: 6 credits of Econ. 510 and Math. 409.

EDUCATION OF EXCEPTIONAL CHILDREN (E E C)

Robert M. Smith
In Charge of Graduate Programs in Education of Exceptional Children
120 Special Education Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors Bliesmer, French, Heilman, McDonald, and Siegenthaler; Associate Professors Frick, Regal, and Smith.

Graduate Faculty, Associate Members: Associate Professor Berlin, Assistant Professor Cartwright.

Exceptional children are those who deviate so far from average in physical, intel-

lectual, emotional, or social characteristics that they cannot profit adequately from the usual public school program. It is the purpose of this program to prepare teachers, researchers, administrators, and college and university teachers in the areas encompassing the education of the mentally retarded, gifted, emotionally maladjusted, neurologically impaired, or crippled. A multidisciplinary approach is emphasized.

Prerequisites for a master's program include: a valid teaching certificate and 10 credits (2 of which must be in a practicum) in the education of exceptional children.

Applicants for doctoral study shall show evidence of (1) having completed a master's degree with "A" quality grades on at least one third of the graduate courses and (2) attaining a minimum score of 500 on both portions of the Graduate Record Examination, or 50 on the Miller Analogies Test, or 35 on the Quantitative Educational Device.

Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

EDUCATION OF EXCEPTIONAL CHILDREN (E E C)

400. Introduction to Exceptional Children (3)
401. Educational Adjustments for Exceptional Children (3)
403. Curriculum Development for Exceptional Children (2-6)
405. Practicum in the Education of Exceptional Children (1-12)
410. The Mentally Retarded (3)
420. The Mentally Gifted (3)
440. (S.P.A. 440) Survey of Speech and Hearing Disorders (3)
444. (El.Ed. 444) Reading Disabilities (2-3)
445. (El.Ed. 445, Sec.Ed. 445) Techniques in Remedial Reading (2-6)
454. Diagnosis of Educational Disabilities (3)
470. The Emotionally Disturbed (3)
472. Educational Problems of Urban Alienated Youth (3)
480. The Neurologically Impaired (3)

500. Seminar in Special Education (1-9) Continuing series of professional seminars designed to provide a forum for discussion of current and classical research concerning exceptional children. Prerequisites: Ed.Psy. 400 and 6 credits in education of exceptional children.

501. Administration and Supervision of Educational Programs for Exceptional Children (2-3) Problems connected with the instituting and organizing of classes for atypical children; the legal phases, finances, teaching personnel, pupil personnel, housing, equipment, courses of study, curriculum, etc. Prerequisites: E.E.C. 401 and Ed.Ser. 480 or teaching or administrative or supervisory experience.

502. Internship in Special Education (2-10) Internship to take place in schools or educational situations where student is not regularly employed, under supervision of graduate faculty. Prerequisite: E.E.C. 405 or teaching experience.

509. Problems, Projects, and Area Studies in Special Education (1-9) May not be used for thesis credit. Prerequisite: 12 graduate credits in special education.

510. Problems in the Education of the Mentally Retarded (2-4) Study of existing curriculums, instructional practices, educational programs; experimentation in curriculum building and materials construction. Prerequisites: teaching experience and E.E.C. 410.

520. Problems in the Education of the Mentally Gifted (2-4) Analysis of educational needs of mentally gifted; curriculum construction and curricular materials. Prerequisites: teaching experience and E.E.C. 420.

545. (S.P.A. 545) Cerebral Palsy (3) Etiology and symptomatology of cerebral palsies; diagnosis and treatment of communication problems; the multi-professional habilitative program. Prerequisite: S.P.A. 444.

546. (S.P.A. 546) Aphasia and Allied Disorders (3) Aphasia and related disorders in adults and children: etiology, diagnosis, and treatment. Prerequisite: S.P.A. 444.

554. Psychological and Educational Evaluation of Exceptional Children (3) Administration and interpretation of individual tests other than the Stanford-Binet, WISC, WAIS. Prerequisite: Psy. 559.

570. Problems in the Education of the Emotionally Disturbed (2-4) Prerequisite: E.E.C. 470.

572. Seminar in the Education of Alienated Groups (2) A study of the alienated and educational issues of coping with problems of social, cultural, and economic deprivation. Prerequisite: E.E.C. 472.

573. Problems of Research with Alienated Groups (2) A seminar to review and design research studies for the education and training of alienated groups. Prerequisites: E.E.C. 472, 572.

580. Problems in the Education of the Neurologically Impaired (2-4) Prerequisite: E.E.C. 480.

EDUCATIONAL ADMINISTRATION (EDADM)

Patrick D. Lynch
In Charge of Graduate Programs in Educational Administration
222 Education Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors DeLacy, Lutz, McAulay, Remaley, and Willower; Associate Professor Bosch.

Graduate Faculty, Associate Members: Professor Lynch, Associate Professor Kohl.

Professional preparation programs are offered at the master's and doctor's degree levels for elementary and secondary school personnel whose objectives are to become principals, supervisors, superintendents, state education department personnel, professors of educational administration, and/or researchers in educational administration.

Requirements for admission to a graduate program in educational administration include 18 approved undergraduate credits in education and psychology. Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

All candidates who seek M.Ed. and M.S. degrees in educational administration shall complete programs embracing 30 graduate credit hours. In only rare instances, however, to fulfill unusual objectives will candidates be permitted to work toward the M.S. degree.

Candidates for the D.Ed. and Ph.D. degrees are required to complete a minimum of three consecutive terms in residence.

From the time of initiation of a 600-level thesis research program, all doctoral candidates shall continuously register for a minimum of 2 credits per term until the

termination of the graduate program. Failure to register for doctoral thesis credits in any term shall be considered automatic withdrawal.

Specific requirements with respect to the Ph.D. and D.Ed. degrees may be learned from a departmental bulletin that is available upon request.

Although candidates are required to specialize in a field of educational administration, they are also encouraged to acquire a general education in the social sciences, the behavioral sciences, and the humanistic foundations.

EDUCATIONAL ADMINISTRATION (EDADM)

427. (Econ. 427) Economics of Education (3)
460. Introduction to Adult Education (3)
480. Educational Administration (2-3)

528. (Pl.Sc. 528) Politics and Education (3) Social forces which shape the educational system and determine national, state, and local educational policies.

533. The Politics of Local School Districts (3) The methodology of studying political decision-making and the theory and practice of politics in local school districts. Prerequisite: 6 credits of sociology, anthropology, or political science.

565. Personnel and Grievance Administration (2-3) Practice and theory of personnel supervision at the central office and building level, including contract administration and grievance handling. Prerequisites: 18 credits in education and three years' teaching experience.

566. Elementary School Organization and Supervision (2-3) The organizational context of the elementary school, its relationship to supervision and the improvement of instruction.

567. Secondary School Organization and Supervision (2-3) The organizational context of the secondary school, its relationship to supervision and the improvement of instruction. Prerequisite: three years' teaching experience.

568. The Principalship (2-3) For elementary and secondary principals. The administrative and management tasks of building administration. The social system, change, and community relationships.

569. Principalship Seminar (2-3) The study and application of interdisciplinary based products and processes in the various organizational units within the educational system.

571. The Educational Plant (2-3) School plant needs in terms of school population and curriculums; the building survey, developing a plant program, the building site, plant utilization, operation and maintenance, heating and ventilation, equipment, school building costs and finance. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.

572. Public Relations for School Administrators (2-3) School-community relationships; social structure, social change, and the schools; case studies of community-school problems. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.

573. Public School Finance (2-3) Financing of public education in relation to organization and control; the conceptual basis for local financial administration; taxation, state and federal aid, school revenue, and money management. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.

574. Theory and Practice of Educational Negotiations (2-3) Theoretical framework, bargaining strategies, legislation, administrative roles, agreements, etc.

Prerequisites: Ed.Adm. 480 or teaching or administrative or supervisory experience, and previous work in school administration.

575. Administration of Adult Education in the Public Schools (3) The organization of a program of adult education; its legal status, finances, selection of teachers, learning personnel, housing, and other administrative problems connected with adult education. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.

576. Legal Aspects of School Administration (3) Legal bases for the organization and administration of school districts and schools; the powers, rights, privileges, and responsibilities of school corporations, school boards, administrators, and personnel; the law and fiscal policies; the course of study, textbooks; contracts; taxes, torts; records; agents; and the judicial decisions involved. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.

578. Dynamic Factors in School Administration (2-3) Intraorganizational relationships; administration and the school as a social system; formal and informal organization. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.

579. Public School Business Administration (2-3) Business management applied to school management problems; budgeting, accounting, purchasing, insurance, school equipment, cafeteria management; transportation, salaries, personnel management, and auxiliary and coordinate agencies. Prerequisites: Ed.Adm. 480 or teaching or administrative or supervisory experience; Ed.Adm. 573.

580. The Use of Theory in Educational Administration (1-6) Administrative theories applied to educational organizations. Prerequisites: Ed.Adm. 480, 6 credits in educational administration.

581. Field Research in Educational Administration (2-3) Methods of appraisal of an educational program; planning for expansion, consolidation, or reduction of educational offerings. Prerequisites: Ed.Adm. 480, 6 credits in educational administration.

582. Internship in Administration and Supervision (1-6) Internship to take place in schools or educational situations where student is not regularly employed, under supervision of graduate faculty.

591. Seminar in Public School Research (1-4) Doctoral candidates present outlines of their dissertations to the Graduate Faculty of the department and advanced graduate students.

596. Seminar in Education (1-9) Conferences and discussions designed to meet the need for special study of particular fields in education. Prerequisite: 12 credits of graduate work in education.

597. Workshop in Current Educational Problems (1-6) For administrators, supervisors, experienced elementary and secondary teachers, guidance workers; administrative, supervisory, and instructional problems involved in an emerging educational program. Prerequisite: 12 credits of graduate work in education.

598. Problems, Projects, and Area Studies in Education (1-6) Independent work in the study of topics in education or the development of new curriculums, materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of the department head.

EDUCATIONAL PSYCHOLOGY (EDPSY)

WILLIAM RABINOWITZ, *Head of the Department*
311 Education and Psychology Center

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors DiVesta, French, Games, Lathrop, Mitzel, Rabinowitz, Thevaos, and Withall; Associate Professors Impellitteri and Seibel; Mr. Greenhill.

Graduate Faculty, Associate Members: Associate Professor Snyder, Assistant Professor Weener.

Graduate work is offered in the general field of educational psychology. Students may specialize and do research in school learning, educational and psychological measurement, statistics and research design as applied to education, and the psychology of instructional systems. Other areas of study related to educational psychology, such as counseling and guidance, clinical psychology, and special education, are offered in other departments of the University.

Special facilities include a research design laboratory, a laboratory for computer-assisted instruction, a self-instruction media laboratory, facilities for film production and editing, and a closed-circuit television studio in Chambers Building used for both research and instruction. Facilities in other departments available to students majoring in educational psychology are the Nursery School, the Psychology Clinic, the Reading Center, the Special Education Center for Children, the Division of Instructional Services, and the Speech and Hearing Clinic. The Computation Center, with several computer systems, is available for use in graduate student research.

Requirements for admission include a broad undergraduate background including some college mathematics and a minimum junior-senior scholastic average of 3.00. Exceptions may be made for students with special backgrounds, abilities, and interests. Applicants are required to submit scores on either the Graduate Record Examination or the Miller Analogies Test. Applicants with a master's degree will be required to show more than minimum success in graduate study, including at least one third of their graduate credits of "A" quality.

Doctoral degree requirements include a major emphasis in one of the above areas of educational psychology with minor emphasis in two related areas (one being in this department). Typically, the doctoral program of study would include at least one course in each of the following areas: research methods, educational and/or philosophical foundations, computer science, human learning, instructional media, measurement, social or industrial psychology, clinical psychology, experimental psychology, and developmental psychology.

EDUCATIONAL PSYCHOLOGY (EDPSY)

400. STATISTICAL INTERPRETATION OF EDUCATIONAL RESEARCH (2)
406. APPLIED PARAMETRIC AND NONPARAMETRIC STATISTICS IN EDUCATION (3)
407. REGRESSION AND CORRELATION METHODS FOR EDUCATIONAL DATA (2)
421. LEARNING PROCESSES IN RELATION TO EDUCATIONAL PRACTICES (3)
450. (Psy. 450) PRINCIPLES OF MEASUREMENT (3)
451. APPRAISAL AND INTERPRETATION OF STANDARDIZED GROUP TESTS (2)
475. INTRODUCTION TO EDUCATIONAL RESEARCH (2)
476. EXPERIMENTATION IN EDUCATIONAL PSYCHOLOGY (3)

501. CURRENT TOPICS IN EDUCATIONAL PSYCHOLOGY (2-6) Study of the current literature in educational psychology with emphasis on historical and theoretical aspects of important areas of investigation. Prerequisites: Ed.Psy. 406, 450, and 421.

506. Advanced Techniques for Analyzing Educational Experiments (2) Advanced techniques for research in education; analysis of covariance; repeated measures; randomized block designs; Latin square; and other experimental arrangements Prerequisites: Ed.Psy. 406 and 407, or Psy. 415.

507. Multivariate Procedures in Educational Research (3) Introduction to matrix algebra, computer programming, multiple regression analysis, multiple and canonical correlation, multiple discriminant analysis, classification procedures, factor analysis. Prerequisites: Ed.Psy. 406 and 407, or Psy. 415.

512. Group Processes in the Classroom (2) Basic concepts and perspectives in the study of group processes; instructional group interaction; analysis of classroom behavior.

513. Individual and Group Differences (2) Historical and contemporary attempts to relate individual differences to important social and educational issues. Prerequisite: Ed.Psy. 400 or Psy. 15.

519. Psychological Foundations for College Teaching (2) Psychological, sociological, and organizational variables which influence college student behavior. Designed for graduate students who anticipate careers in college teaching.

520. Application of Learning Models to Classroom Practices (2) Probabilistic models of acquisition in complex human learning; assessment of learning in the classroom that is amenable to such analysis. Prerequisite: Ed.Psy. 421.

522. Concept Learning in the Schools (2) Study of theory and research related to concept formation and attainment with implications for instruction. Prerequisite: Ed.Psy. 421.

523. Problem Solving in the Schools (2) Examination of theory and research related to cognitive processes in problem solving with implications for educational practice. Prerequisite: Ed.Psy. 421.

524. Theories of Learning and Instruction (3) Study of major classical theories of learning and recent developments in learning and instructional theory. Prerequisite: Ed.Psy. 421.

530. Theory and Research in Programmed Learning (3) Research and trends in programmed learning; preparation of short programmed sequences for experimental analysis. Prerequisites: Ed.Psy. 450 and 421, or Psy. 404.

532. Survey of Media Research (3) Systematic study of media research in educational applications of television, still and motion pictures, graphic and simulated environments. Prerequisite: Ed.Psy. 400 or Psy. 415.

550. Design and Construction of Psychological Measures (3) Lecture-practicum involving planning, construction, administration, and analysis of a psychological test; lectures stress construct validity, item analysis, and predictive validity. Prerequisite: Ed.Psy. 450.

554. Theories of Psychological Measurement (2) Basic true-score and error models; their extensions to test reliability and test validity; problems of item analysis and weighting. Prerequisite: Ed.Psy. 450.

558. Scaling Educational and Psychological Measures (2) Unidimensional and multidimensional scaling models with emphasis on psychometric methods and brief attention to psychophysical methods. Prerequisite: Ed.Psy. 450.

575. Seminar in Educational Psychology (3-9) A seminar dealing with specific topics in educationl psychology. Open to advanced students in the behavioral sciences.

591. Problems and Projects in Educational Psychology (1-6) Independent work on special topics.

ELECTRICAL ENGINEERING (E E)

Arthur H. Waynick, *Head of the Department*
118 Electrical Engineering East

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Brown, Cross, Ferraro, Holt, Lewis, Mentzer, Nisbet, Ross, Volz, and Waynick; Associate Professors Adams, Das, Etzweiler, Hale, Lachs, Lee, and Quinn; Assistant Professor Seliga.

Graduate Faculty, Associate Members: Adjunct Professor Jeffreys; Assistant Professors Bishop, Bredeson, Delansky, Magoulas, McMurtry, and Robinson.

Course offerings and research facilities are available in the following areas: antennas, communications systems (conventional and laser), computers (including digital, analog, hybrid, and network analyzer), control systems, energy conversion and distribution, electron devices, information theory, ionosphere research (geomagnetism and aeronomy), microwave theory and techniques, networks, plasmas and MHD, power system analysis, solid state devices, servomechanisms, and wave propagation.

A bachelor's degree in engineering or science is required with courses in electrical circuits, fields, and electronics. Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

ELECTRICAL ENGINEERING (E E)

401. Network Analysis for Technology Teachers (3)
402. Electronic Devices and Circuits for Technology Teachers, Part I (3)
403. Electronic Devices and Circuits for Technology Teachers, Part II (3)
404. Electromechanical Energy Conversion for Technology Teachers (3)
411. Principles of Electromagnetic Fields (3)
413. Linear Network Analysis (3)
417. System Theory (3)
419. Solid State Devics (3)
421a,b,c,d. Electrical Engineering Problems (1-10)
425. Symmetrical Components (3)
428. Linear Control Systems (3)
429. Control System Design (3)
432. Microwave Methods and Analysis (3)
435. Engineering Analysis (3)
437. Engineering Applications of Complex Variables (3)
438. Electromagnetic Theory and Radiating Systems (3)
441. Active Circuits (3)
448. Linear Electronic Design (3)
449. Digital Electronic Design (3)
450. Network Analysis (3)
459. Introduction to Statistical Theory of Communications (3)
461. Fundamentals of Power System Stability (3)
470. Electronic Analog Computers (3)
471. Logical Design of Switching Systems (3)

472. Introduction to Digital Computer Systems (3)
490. (Nuc.E. 490) Introduction to Plasma Theory (3)
491. Plasma Phenomena and Diagnostics Laboratory (3)

514. Quantum Electronics (3) Quantization of electromagnetic fields; quantum statistics of attenuators and amplifiers; analysis of laser oscillators; Glauber P-representation; photon detection and coherence. Prerequisite: Phys. 561.

520. Seminar (1) Required of all graduate students in electrical engineering. Conferences, reading, and presentation of technical papers.

521. Advanced Electrical Engineering Problems (1-10)

523. Nonlinear Analysis (3) Transient and steady state analysis of nonlinear physical systems; phase plane analysis, iterative techniques, singular points, and subharmonics. Prerequisite: E.E. 435.

525. Symmetrical Components (3) Polyphase cricuits and machines under unbalanced conditions of operation including effects of rotating machines upon distribution and transmission system performance; characteristics of phase converters and single-phase operation of polyphase systems. Prerequisite: E.E. 425.

526. Semiconductor Electronics (3) Advanced semiconductor theory and applications to transistors and other semiconductor devices; modern semiconductor circuits. Prerequisite: E.E. 448.

527. Linear Control Systems (3) Continuous and discrete-time linear control systems; state variable models; analytical design for deterministic and random inputs; time-varying systems stability. Prerequisite: E.E. 428 or M.E. 455.

528. Nonlinear Control Systems (3) Design of nonlinear automatic control systems; numerical methods; phase-plane methods; describing functions; optimum switched systems; Liapunov and Popov stability. Prerequisite: E.E. 428 or M.E. 455.

529. Optimal Control (3) Variational methods in control system design; classical calculus of variations, dynamic programming, maximum principle; optimal digital control systems; state estimation. Prerequisite: E.E. 527.

530. Optimal Control (3) Minimum-time and minimum-fuel controls; generalizations of the maximum principle; computational methods in optimal control. Prerequisite: E.E. 529.

532. Ultra-High-Frequency Engineering (3) Theory of wave guides and discontinuities, resonant cavities, traveling wave oscillators and devices; interaction of fields with matter. Prerequisite: E.E. 432.

535. Engineering Analysis (3) Applications of mapping methods, series and integral representations to the solution of boundary value problems in electrical engineering. Prerequisite: E.E. 437.

536. Transform Methods in Linear Analysis (3) Analysis of linear systems by Laplace transform with emphasis on periodic nonsinusoidal forcing functions. Prerequisite: E.E. 435.

538. Electromagnetic Engineering (3) Electromagnetic fields using the Maxwell-Lorentz equations as applied to vector fields, special solutions to scattering, diffraction, and radiation problems. Prerequisite: E.E. 438.

550. Network Synthesis (3) Positive real functions, realizability conditions, synthesis of driving point immittances, synthesis of two-terminal pair networks, transfer function synthesis. Prerequisites: E.E. 437, 450.

560. Statistical Theory of Communications (3) Generalized harmonic analysis; the application of correlation and convolution to the detection of signals in noise; various special topics. Prerequisite: E.E. 459 or Math. 409.

561. Information Theory (3) Mathematical measurement of information; information transfer in discrete systems; redundancy, efficiency, and channel capacity; encoding systems. Prerequisite: E.E. 459 or Math. 409.

569. Simulation of Biomedical Systems (3) Simulation of biological and medical systems on analog and digital computers; direct electrical analogs; modeling techniques. Prerequisites: E.E. 470 or Cmp.Sc. 401 and Biol. 11.

570. Advanced Electronic Analog Computers (3) Advanced techniques of analog computation and simulation; machine and problem errors; nonlinear differential equations. Prerequisite: E.E. 470.

571. Digital Computers: Recent Developments and Advanced Logic (3) Advanced treatment of logical design; discussion of topics of current interest in the general area of digital computers. Prerequisite: E.E. 471.

580. Radio Waves and the Ionosphere (3) The magneto-ionic theory of ionospheric wave propagation; ray-optical approximations; determination of ionization profiles; full wave solutions; nonlinear and coupling effects. Prerequisite: E.E. 62 or 438 or Phys. 557.

581. Constitution of the Ionosphere (3) Properties of neutral and ionized atmosphere above 60 km; photochemical processes; solar, meteoric perturbations of the ionosphere; large-scale movements in ionization.

590. (Nuc.E. 590) Theory of Plasma Waves (3) Solutions of the Boltzmann equation; waves in bounded and unbounded plasmas; radiation and scattering from plasmas. Prerequisite: E.E. 490.

591. (Nuc.E. 591) Plasma Theory (3) Advanced topics in kinetic theory, fluctuation theory, microinstability, and turbulence. Prerequisite: E.E. 590.

592. Engineering Magnetohydrodynamics (3) Fluid properties; derivation of MHD equations; channel flows; MHD waves; stability theory; power generation techniques. Prerequisite: E.E. 438.

ELEMENTARY EDUCATION (EL ED)

Gerald R. Bosch
In Charge of Graduate Programs in Elementary Education
148 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors Bixby, Bliesmer, Brewer, Corle, Heilman, McAulay, and Riedesel; Associate Professors Bosch and Zafforoni.
Graduate Faculty, Associate Members: Professor Alessandro, Associate Professor Alfke.

The graduate programs provide advanced professional preparation for early childhood and elementary school teachers, curriculum specialists, elementary supervisory personnel, elementary school principals, and elementary teacher education personnel.

For admission 18 credits in elementary education and teaching experience are required. Students who present a 2.70 junior-senior average will be acceptable to the

department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

The Master of Education degree in elementary education is also offered at the Capitol Campus.

ELEMENTARY EDUCATION (EL ED)

426. Problems of Elementary School Arithmetic (2-3)
433. Teaching Social Studies in the Elementary Grades (2-3)
436. Teaching of Conservation of Natural Resources in the Elementary School (3)
437. Teaching of Conservation of Natural Resources in the Elementary School (3)
438. Teaching Science in the Elementary School (1-3)
443. The Elementary School Reading Program (2-3)
444. (E.E.C. 444) Reading Disabilities (2-3)
445. (E.E.C. 445, Sec.Ed. 445) Techniques in Remedial Reading (2-6)
449. Teaching Children's Literature (2-3)
453. Special Problems in the Teaching of Elementary School English (2-3)
461. Elementary Education (2-3)
467. Advanced Theory of Kindergarten (3)
479. Measurement of Achievement in the Elementary School (2-3)
485. Workshop in Selected Studies in Elementary Education (1-6)

511. Supervision of Student Teachers (3) A course in supervision for master teachers, department heads, and college teachers with supervisory responsibilities in teacher education. Prerequisites: teaching experience and 18 credits in education, including at least 5 in methods.

520. Internship in Elementary Education (3-6) Internship to take place in schools or educational situations where student is not regularly employed, under supervision of graduate faculty.

526. Applications of Research in the Teaching of Elementary School Mathematics (3) Research applications dealing with the study of curriculum, materials, evaluation, teaching, learning, and supervision of elementary school mathematics. Prerequisites: El.Ed. 426 and elementary teaching experience; Ed.Psy. 400.

533. Problems and Issues in Elementary School Social Studies (3) Historical-philosophical bases for the social studies: curriculum development, research findings and techniques, learning resources, and promising proposals. Prerequisites: El.Ed. 433 and elementary school teaching experience.

546. (Sec.Ed. 546) Seminar on Reading Instruction (3-6) Research, procedures, and materials in reading readiness, word perception, basic reading skills, vocabulary development, reading in content subjects. Prerequisite: El.Ed. 443 or Sec.Ed. 443.

557. Reading Clinic Practice: Remedial Procedures (1-9) Practicum in special classes for reading disabilities; corrective and remedial procedures; specific procedures for correction of various types of reading disabilities. Prerequisite: El.Ed. 444.

559. Reading Clinic Research (1-15) Prerequisites: El.Ed. 443 or Sec.Ed. 443; El.Ed. 444.

562. Problems of Elementary Education (2-3) Problems seminar for experienced educators. Prerequisite: 12 credits in education and psychology, including 6 in elementary education.

563. Seminar in Contemporary Issues in Elementary Education (1-3) Conferences and discussions designed to meet the needs of experienced teachers and principals in the field of elementary education. Prerequisites: 6 credits in elementary education and teaching experience.

564. Organization of the Elementary School Curriculum (2-3) Principles underlying curriculum construction. Primarily for elementary education majors. Prerequisite: El.Ed. 311 or teaching experience.

585. Workshop in Current Elementary School Problems (1-6) For experienced elementary school teachers: administrative, supervisory, and instructional problems involved in an emerging educational program. Prerequisite: 12 credits of graduate work in education.

594. Seminar in Elementary Education (1-9) Conferences and discussions designed to meet the needs for special study of particular fields in education. Prerequisite: 12 credits of graduate work in elementary education.

598. Problems, Projects, and Area Studies in Elementary Education (1-6) Independent work in the study of topics in elementary education or the development of new curriculums, materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of the department head.

ENGINEERING ACOUSTICS (E ACS)

Richard O. Rowlands
Chairman of the Committee on Engineering Acoustics
461 Ordnance Research Laboratory

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty, Senior Members: Professors Boggs, Brown, Johnson, Kendig, Rowlands, and Snowdon; Associate Professor Baker.

Graduate Faculty, Associate Members: Associate Professor Farwell, Mr. Boyd.

The aim of this program is to enable the student interested in acoustics to obtain an integrated program of courses covering the fundamentals of acoustical science and the biological, communications, and engineering applications of acoustics.

Programs are arranged through a selection of appropriate courses offered by the several departments of science, engineering, and arts, as well as those specifically in the area of engineering acoustics.

Areas of concentration include acoustic signal processing, architectural acoustics, noise and vibration, physical acoustics, speech and hearing, and underwater acoustics. Thesis research in the various areas may be conducted in relevant departments and in the Ordnance Research Laboratory.

Entering students should hold a bachelor's degree in physics, biology, engineering, architecture, mathematics, or speech and hearing, or in a closely related field; and they should have had at least one year of physics and mathematics including integral calculus. Students who present at least a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

ENGINEERING ACOUSTICS (E ACS)

500. Special Problems in Acoustics (1-6) Provides training in selected areas of acoustics by means of supervised investigations or studies. Prerequisite: Phys. 443.

501. Engineering Acoustics Seminar (1 per term) Recent developments and current research in engineering acoustics.

511. Underwater Sound Propagation (3) Theoretical and empirical treatment of sound propagation in the ocean, including effects of the environment, characteristics of targets, and transducers.

512. Sonar Engineering (4) Theoretical and empirical treatment of problems related to the use of underwater sound in target detection and ranging.

513. Modern Acoustic Signal Processing (4) Probability review, representation of signals, noise processes, optimum filtering, ambiguity functions, linear and nonlinear signal processing, application to sonar systems.

514. Electroacoustic Transducers (4) The theory, design, and calibration of passive, linear, reciprocal electroacoustic transducers for use in both air and water media. Prerequisite: Phys. 443.

515. Acoustics in Fluid Media (3) Wave propagation in stationary and moving fluids; acoustic radiation and scattering; standing waves in ducts and cavities. Prerequisites: E.Mch. 425A, Phys. 443.

ENGINEERING MECHANICS (E MCH)

Robert M. Haythornthwaite, *Head of the Department*
105 Hammond Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty, Senior Members: Professors Davids, Hardenbergh, Haythornthwaite, Hu, Jaunzemis, Neubert, and Vierck; Associate Professor Sharma.

Graduate Faculty, Associate Members: Associate Professors Kiusalaas and Zamrik, Assistant Professor Hayek.

Graduate study is available in the following areas: (1) dynamics, including mechanics of rigid bodies, vibration, and stress waves; (2) mechanics of deformable bodies including elasticity, plasticity, viscoelasticity, and continuum mechanics; (3) mechanics of materials and structures including mechanical properties, plates and shells, and plastic analysis; (4) experimental mechanics including experimental stress analysis, photoelasticity, and experimental vibration.

The entering student must hold a bachelor's degree in engineering or science and have satisfactorily completed undergraduate courses in mechanics. Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

ENGINEERING MECHANICS (E MCH)

400.	Advanced Strength of Materials (3)	*Mr. Zamrik*
401.	Elements of Vibrations (3)	*Mr. Vierck*
402.	Applied and Experimental Stress Analysis (3)	*Mr. Conway*
403.	Mechanics of the Solid State (4)	*Mr. Queeney*
404.	Research in Engineering Mechanics (1-6)	
407.	Elements of Computer Methods in Engineering (3)	*Mr. Sharma*
408.	Elasticity and Engineering Applications (3)	*Mr. Kiusalaas*
409.	Advanced Mechanics (3)	*Mr. Hardenbergh*

410. Mechanics of Space Flight (3) *Mr. Hardenbergh*
412. Experimental Methods in Vibrations (3) *Mr. Neubert*
413. Plastic Analysis of Structures (3) *Mr. Hu*
414. Elements of Material Science (3) *Mr. Queeney*
421. Continuum Mechanics (3) *Mr. Jaunzemis*
422. Continuum Mechanics (3) *Mr. Jaunzemis*
446. Mechanics of Viscoelastic Materials (3) *Mr. Sharma*

500. Advanced Mechanics of Materials (3-6) Strain energy methods; special problems in bending and torsion; curved bars, beams on elastic foundations; thick-walled cylinders, shrink-fit assemblies, and rotating discs; thin-walled pressure vessels; bending of thin plates; buckling of bars and plates. Prerequisite: E.Mch. 13.
Messrs. Kiusalaas and Sharma

506. Experimental Stress Analysis (3) Experimental methods of stress determination including photoelasticity, stress coat and electric strain gauge techniques; stress analogies; strain rosettes for combined stress determinations. Prerequisite: E.Mch. 408 or 507.

507. Theory of Elasticity and Applications (3) Equations of equilibrium and compatibility; stresses and strains in beams, curved members, rotating discs, thick cylinders, torsion and structural members. Prerequisite: E.Mch. 13.
Messrs. Hu and Kiusalaas

508. Theory of Elastic Stability and Applications (3) Buckling of slender and short members; buckling of I-beams; stability of thin-walled constructions; thin-walled cylinders subjected to external pressures; applications to structural parts including aircraft members. Prerequisites: E.Mch. 12, 13. *Mr. Kiusalaas*

509. Theory of Plates and Shells (3) Bending and buckling of plates; elastic foundations; deformation of shells, multilayer shells, stress and stability analysis, weight optimization, application problems. Prerequisite: E.Mch. 13. *Mr. Kiusalaas*

514. Engineering Mechanics Seminar (1 per term) Current literature and special problems in engineering mechanics. *Mr. Davids*

516. Mathematical Theory of Elasticity (3) Fundamental equations and problems of elasticity theory; uniqueness theorems and variational principles; methods of stress functions and displacement potentials; applications. Prerequisite: E.Mch. 540. *Mr. Jaunzemis*

520. Advanced Dynamics (3) Dynamics of a particle and of rigid bodies: Newtonian equations in moving coordinate systems; Lagrange's and Hamilton's equations of motion; special problems in vibrations and dynamics. Prerequisites: E.Mch. 12, Math. 72 or 431. *Mr. Jaunzemis*

521. Stress Waves in Solids (3) Theoretical fundamentals, classic experiments; recent advances, including scabbing applications, plastic waves, penetration mechanics, impact, and numerical methods. Prerequisites: E.Mch. 12; Math. 405 or E.Mch. 524. *Mr. Davids*

522. Theory of Vibrations (3) Mathematical theory of vibrating systems; damping phenomena; forced vibrations; analogy between mechanical and electrical vibrations; transverse and torsional oscillation of shafts; vibration of strings, beams, membranes, and plates. Prerequisites: E.Mch. 13, Math. 72 or 431.
Messrs. Vierck and Neubert

523. Computer Methods in Engineering Analysis (3) Finite elements, finite differences, and matrix methods applied to dynamics, elasticity, wave propagation, heat conduction, structural analysis, and fluid flow. Prerequisites: Cmp.Sc. 401, Math. 72. *Mr. Davids*

524. Mathematical Methods in Engineering (3 per unit) Prerequisite: A.M. 451 or E.E. 435 or M.E. 452. *Messrs. Davids and Hayek*
Unit A (3) Basic tools, including Fourier, Legendre, and other orthogonal series, special functions, Laplace transforms. Applications in mechanics and other fields. Prerequisite: Math. 73.
Unit B (3) Solution techniques for boundary-value problems in curvilinear coordinates, integral transforms, Green's functions, potentials, applications to diffusion, vibration, wave-propagation. Prerequisite: E.Mch. 524A or Math. 431.

525. Vibration and Shock in Damped Mechanical Systems (3) Rubberlike materials; vibration isolation; structural impedance; wave propagation; multi-force excitation of beams; Timoshenko beams; transients; shock spectra; damage; nonlinear response. Prerequisite: E.Mch. 401 or 522. *Mr. Snowden*

526. Nonlinear Mechanics (3) Integral curves, singular points, self-sustained oscillations, stability problems, Hill's and Van der Pol's equation, mechanical and electrical applications. Prerequisite: E.Mch. 522. *Mr. Neubert*

527. Structural Dynamics (3) Dynamic behavior of structural systems; normal modes; input spectra; finite element representation of frameworks, plates, and shells; impedance; elastic-plastic response. Prerequisites: E.Mch. 12, 13. *Mr. Neubert*

528. Experimental Methods in Vibrations (3) Investigation of one or more degrees of freedom, free and forced mechanical vibrations, vibration properties of materials, nondestructive testing. Prerequisite: E.Mch. 401 or 522. *Mr. Neubert*

530. Solid State Mechanics (3) Relation between solid state physics and mechanics; mechanical properties for static, fatigue, creep, and impact conditions; high temperature properties; applications. Prerequisite: E.Mch. 14. *Messrs. Hu and Zamrik*

531. Theory of Plasticity and Applications (3) Yield condition; plastic stress-strain relations; theory of slip-line fields; applications to bending, torsion, axially symmetric bodies, metal processing. Prerequisite: E.Mch. 507. *Mr. Hu*

533. Determination of Mechanical Properties (3) Experimental methods for determining hardness, elastic constants, creep behavior, fatigue strength, plastic flow, and dynamic properties of metals. Prerequisite: E.Mch. 14 or 530. *Mr. Hu*

534. Photoelasticity (3) Analysis of polariscopes; isoclinics, isochromatics, and stress trajectories; two- and three-dimensional photoelastic methods; determination of principal stresses; model preparation. Prerequisite: E.Mch. 408 or 507.

540. Introduction to Continuum Mechanics (3) Algebra and analysis of tensors; balance equations of classical physics; the linear theories of continuum mechanics. Prerequisite: E.Mch. 421. *Mr. Hayek*

541. Nonlinear Theories of Continuum Mechanics (3) The general theory of constitutive equations; finite deformations and elasticity; flow and fluidity; viscoelasticity, modern topics. Prerequisite: E.Mch. 540. *Mr. Hayek*

546. Theory of Viscoelasticity and Applications (3) Linear and nonlinear viscoelastic theories; generalized isotropic and anisotropic viscoelastic stress-strain relations. Prerequisite: E.Mch. 507. *Mr. Sharma*

550. Studies in Engineering Mechanics (1-6) Studies in any field of engineering mechanics.

570. Random Vibrations in Structural Mechanics (3) Probability theory applied to random vibrations of linear and nonlinear systems; excitation by ground motion, turbulence, and noise; acoustic damping. Prerequisite: Aersp. 411 or E.Mch. 401 or 522. *Mr. Neubert*

ENGINEERING SCIENCE (E SC)

Samuel S. Lestz
Chairman of the Engineering Graduate Committee for Off-Campus Programs
302 Mechanical Engineering Building

Degree Conferred: M.Eng.

A program leading to the degree of Master of Engineering with a major in engineering science is offered at the Behrend and King of Prussia Graduate Centers and at the Capitol Campus near Harrisburg. Details of the program may be obtained by writing directly to these locations. Addresses are given on page 2.

The program is designed to provide a broad, advanced education in the engineering sciences with some specialization permitted in the area of a student's major interest. It is offered specifically to permit practicing engineers to pursue advanced studies through evening classes while in full-time employment in industry in the area. Courses offered for the program are all established and controlled by the resident departments at the University Park Campus.

The credit requirements in this major will be satisfied by an appropriate combination of core courses and elective courses. The core courses include offerings in mathematics and in several branches of engineering which have been selected because of their general character and breadth of applicability to all fields of engineering.

A minimum of 30 credits of course work is required, of which at least 12 must be at the 500 level. A scholarly written report is also required.

A bachelor's degree in engineering or a closely allied field is required for admission. Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

ENGLISH (ENGL)

Henry W. Sams, *Head of the Department*
S-227 Burrowes Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty, Senior Members: Professors Bayard, Condee, Cramer, Davis, Frank, Goldberg, Jewkes, Lewis, Meserole, Price, Rubin, Sams, Weintraub, and Young; Associate Professors Austin, Bressler, Reed, Trachtenberg, Wellwarth, and West.

Graduate Faculty, Associate Members: Associate Professors Borklund, Fitzgerald, Gidez, Hansen, Rogers, and Walden.

A student may specialize in English literature, American literature, philology, or rhetoric. It is preferred that an entering student present 24 credits in English, but 18 credits in English exclusive of survey and freshman courses will be accepted. If the student does not present 18 credits in English, he must make up the deficiency early in his graduate work. A thesis is required of all M.A. candidates in this major.

Students who present a 3.00 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

ENGLISH (ENGL)

406. History of the English Language (3) *Messrs. Bell, Buckalew, and Shedd*
407. History of the English Language for Teachers (3) *Messrs. Bell, Buckalew, and Shedd*
408. Advanced College Grammar (3) *Miss McElwee*
411. Problems of Style (3)
412. The Writing of Fiction (3-6) *Messrs. Klass, Rogers, Rubinstein, and West*
413. Verse Writing (3-6) *Mr. Haag*
414. Biographical Writing (3) *Mr. Weintraub*
415. Nonfiction Writing (3)
418. Advanced Technical Writing and Editing (3-6) *Messrs. Damerst and Houp*
422. Masters of British Literature (3-6)
423. History of British Literature (3) *Mr. Arnold*
424. Movements in British Literature (3)
432. Masters of American Literature (3-6) *Staff*
433. History of American Literature (3) *Mr. Gidez*
434. Movements in American Literature (3-6) *Staff*
435. The American Short Story (3) *Mr. Bressler*
437. American Poetry (3) *Messrs. Davis, Rubin, and Hansen*
438. American Drama (3) *Mr. Wellwarth*
441. Poetry and Prose of the Early 17th Century (3) *Mr. Condee*
442. Poetry and Prose of the Late 17th Century (3)
443. Jacobean and Caroline Drama (3) *Messrs. Arnold and Jewkes*
444. Shakespeare (3) *Messrs. Arnold, Jewkes, Moore, Price, and Reed*
445. Chaucer (3) *Messrs. Bell, Frank, and Shedd*
446. Milton (3) *Messrs. Condee and McAdams*
447. Poetry and Prose of the 16th Century (3) *Mr. Reed*
448. English Drama Before Shakespeare (3) *Mr. Jewkes*
449. Shakespeare (3) *Messrs. Arnold, Jewkes, Moore, Price, and Reed*
451. Poetry and Prose of the Early 18th Century (3) *Mr. Fitzgerald*
452. Poetry and Prose of the Late 18th Century (3) *Mr. Wilson*
455. The Novel in England to Jane Austen (3) *Mr. Fitzgerald*
458. The Drama from Dryden to Sheridan (3) *Mr. Rogers*
461. British Non-Fictional Prose of the 19th Century (3) *Miss Austin*
462. Wordsworth and Coleridge (3) *Mr. Cramer*
463. Byron, Shelley, and Keats (3) *Miss Austin*
465. Victorian Novel (3) *Miss Austin and Mr. Lougy*
466. The American Novel to 1900 (3) *Messrs. Gidez and Hansen*
467. Victorian Poetry (3) *Messrs. Cramer and Lougy*
470. Literature of the British Commonwealth (3)
475. Modern British Fiction (3) *Messrs. Maxwell and West*
476. The American Novel Since 1900 (3) *Mr. Young*
477. British and American Poetry of the 20th Century (3) *Mrs. Rodgers and Mr. Haag*
478. British and Irish Drama Since 1890 (3) *Mr. Weintraub*
481. History of English Literary Criticism (3) *Messrs. Borklund, Gidez, and Mayberry*
488. (C.Lit. 488) Modern Continental Drama (3) *Messrs. Weintraub and Wellwarth*
490. Rhetorical Theory and Practice (3) *Messrs. Holahan and Rubinstein*
491. Literature for Teachers in Secondary Schools (3) *Mr. Bressler*
*498. English Institute (6-12)

* A maximum of 6 credits in one summer.

501. Materials and Methods of Research (4) Materials and techniques of research in English and American literary history; form and content of theses. Required of all graduate students with an English major. *Mr. Meserole*

521. Old English Language (3) An introduction to the main features of the Old English language; readings in simple Old English prose and poetry *Mr. Bell*

522. Old English Literature (3) A reading of the more important poetic works in Old English. *Mr. Bell*

523. Wordsworth and Coleridge (3) Major and some minor works; the pertinent criticism and scholarship; aspects of the period. *Mr. Cramer*

524. Byron and Shelley (3) Major and some minor works; the pertinent criticism and scholarship; aspects of the period.

525. Blake and Keats (3) Major and some minor works; the pertinent criticism and scholarship; aspects of the period. *Miss Austin*

526. Tennyson and Browning (3) *Mr. Cramer*

536. Henry James (3) The development of James as critic, novelist, and short story writer. *Mr. Borklund*

537. Robinson and Frost (3) The art and thought of two American poets who link the traditions of the 19th and 20th centuries. *Mr. Davis*

540. Studies in Elizabethan Prose and Poetry (3-6) *Messrs. Price and Reed*

541. Medieval Studies (3-6) Special problems in medieval English literature. *Mr. Frank*

542. Middle English Literature (3) Introduction to Middle English and its dialects; study of the literature of the period exclusive of Chaucer. *Mr. Bell*

543. Studies in Early 17th Century Literature (3-6) Major poets and prose writers from 1600 to 1660. *Mr. Condee*

544. Restoration Literature (3) Selected studies of writers in England between 1650 and 1700.

545. Chaucer (3-6) Critical study of the *Canterbury Tales* or *Troilus and Criseyde* and minor poems. *Mr. Frank*

546. Milton (3) The poetry and prose of John Milton. *Mr. Condee*

548. Elizabethan and Jacobean Drama (3-6) English drama from 1558 to 1642 exclusive of Shakespeare. *Mr. Jewkes*

549. Shakespeare (3-6) Special problems of sources, chronology, text, characterization, and motivation in the drama. *Messrs. Jewkes, Price, and Reed*

552. Swift and Pope (3) *Mr. Sams*

553. The Age of Johnson (3) The work of Johnson and his circle. *Mr. Fitzgerald*

554. Studies in Early American Literature (3) *Messrs. Meserole and Hansen*

555. The Puritans (3) Critical studies of the principal works of English and American Puritans. *Messrs. Meserole and Hansen*

556. Eighteenth Century British Fiction (3) *Mr. Sams*

557. Early 18th Century British Literature (3) Prose and poetry in the reign of Queen Anne, with special attention to periodical publications. *Mr. Sams*

560. American Romanticism (3) The Romantic movement in American literature of the mid-19th century. *Messrs. Davis, Hansen, and Trachtenberg*

561. Studies in the Romantic Movement (3-6) *Miss Austin*

562. Studies in the Literature of Victorian England (3-6) *Miss Austin, Messrs. Cramer and Weintraub*

564. Studies in 19th Century American Literature (3) The major figures treated will vary from year to year. *Messrs. Rubin, Davis, and Hansen*

573. Studies in 20th Century British Literature (3-6) Major writers and literary movements. *Messrs. Weintraub and West*

574. Studies in 20th Century American Literature (3-6) Major writers and literary movements.

575. James Joyce (3-6) Alternate terms: *Ulysses* and *Finnegans Wake.* Knowledge of *Dubliners* and *A Portrait of the Artist* is assumed.

576. Hemingway and Faulkner (3) The major works. *Mr. Young*

578. Shaw (3) The plays, prose writings, and literary influence of G.B.S. *Mr. Weintraub*

579. T. S. Eliot (3) Major works in poetry, criticism, and drama; pertinent scholarship and criticism. *Messrs. Lewis and Davis*

581. Contemporary Literary Criticism (3) *Messrs. Sams and Borklund*

582. Hawthorne and Melville (3) Detailed study of the major works of both authors and of the relationship between the two men. *Messrs. Young and Gidez*

583. Emerson and Thoreau (3) The significant prose and poetry of the chief American transcendentalists. *Mr. Bressler*

584. Whitman and Dickinson (3) The major texts, with special emphasis on background and language. *Messrs. Rubin and Davis*

585. Twain and Howells (3) The principal works, the relationship between the two men, and their place in American literature. *Mr. Lewis*

587. Franklin and Edwards (3) Studies in the lives, works, and milieu. *Mr. Meserole*

590. Research Problems in British Literature (3-6) Methods of research, problems of bibliography, and evaluation of sources and materials.

591. Research Problems in American Literature (3-6) Methods of research, problems of bibliography, and evaluation of sources and materials.

592. Studies in American Literary Myth (3) An introduction to an interpretive, interdisciplinary study of some representative themes in American literature and culture. *Mr. Young*

593. (C.Lit. 593) Anglo-American Folk Song (3) Survey of relevant literary and ethnological scholarship and field work, European and American, from the early 16th century to the present. *Mr. Bayard*

595. Studies in British Fiction (3-6) *Mr. Weintraub*

596. Studies in American Fiction (3-6) *Messrs. Trachtenberg and Gidez*

597. Studies in American Poetry (3-6) *Messrs. Rubin, Davis, and Hansen*

598. Readings in English (1-6) Programs of readings in English and American literature, designed to meet specific needs of individual students.

ENTOMOLOGY (ENT)

Beckford F. Coon, *Head of the Department*
204 Armsby Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty, Senior Members: Professors Asquith, Coon, and Rutschky; Associate Professors Mumma, Smyth, Snetsinger, and Yendol; Assistant Professor Benton.
Graduate Faculty, Associate Members: Associate Professor Ercegovich, Assistant Professors Kearby and Kim.

A student majoring in entomology may specialize in various areas of economic entomology and in forest entomology, apiculture, insect resistance in plants, arachnology, medical or veterinary entomology, biological control, insect transmission of plant pathogens, ecology, morphology, embryology, taxonomy, physiology, insect behavior, or chemistry of pesticides.

For admission a student is required to have 24 credits in entomology and related biological and physical sciences. Chemistry through organic, physics, mathematics, and statistics are advantageous. A limited deficiency may be made up, without degree credit, while pursuing graduate work.

Students who present a 3.00 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

ENTOMOLOGY (ENT)

401. Medical and Veterinary Entomology (3) *Mr. Kim*
402. Insect Ecology (3) *Mr. Kearby*
403. (Biol. 403) Systematics (3) *Mr. Kim*
405. Insect Morphology (3) *Mr. Rutschky*
411. Insect Physiology (3) *Mr. Smyth*
413. Entomology Seminar (1 per term)
429. Insect Control (3) *Mr. Hower*
431. Special Problems (1-6)
435. Arachnology (3) *Mr. Snetsinger*

506. Immature Insects (3) The morphology and taxonomy of the immature stages of inescts. Spring term, even years. *Mr. Rutschky*

520. Special Topics (1-6)

531. Insect Toxicology (2) General principles of toxicology and survey of the actions of substances toxic to insects. Fall term, odd years.

532. Insect Behavior (2) Orientation reflexes, learning, communication, and social behavior; physiological bases, ecological and evolutionary implications.

535. Biological Control (3) Practical and theoretical aspects of the biological control of arthropod pests. Spring term, even years. *Mr. Yendol*

540. Insect Resistance in Plants (2) Mechanism, expression, permanence, and

measurement of resistance to insects with special reference to farm crops. Spring term, odd years. *Mr. Coon*

EXTENSION EDUCATION (EXTED)

EMORY J. BROWN
Chairman of the Committee on Extension Education
204 Weaver Building

Degrees Conferred: M.Agr., M.Ed.

This program is designed primarily to meet the needs of professional teachers in various extension and adult education positions. The purpose is to train individuals to develop attitudes, understandings, and competencies which enable them to become more effective professional workers. Options have been developed for the Colleges of Agriculture and Human Development. Additional options will be offered as they are developed by other Colleges.

Admission requirements include a strong background in agriculture or home economics and a minimum of 12 credits in the social sciences.

Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

For either degree a minimum of 30 credits is required, in addition to a professional paper. These credits should be distributed as follows: 12 credits in extension core courses, 6 in communication and/or education, and 12 in two areas of agriculture and/or home economics.

FAMILY ECONOMICS AND HOME MANAGEMENT (FE HM)

MARJORIE M. KNOLL
In Charge of Graduate Programs in Family Economics and Home Management
S-110 Human Development Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professor Knoll, Associate Professor Nichols.
Graduate Faculty, Associate Member: Associate Professor Gage.

Those interested in emphasizing a study of home management, family economics, or family housing may do so through this major. There are no specific course requirements for admission. Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

Courses are available in the area of family housing; their descriptions may be found under the offerings of the program in Man-Environment Relations.

In the graduate program family management practices, their effects upon members of the family unit, and the interaction of such practices with the local and national

economy are studied in relation to principles of economics, philosophy, psychology, sociology, and political science.

CONSUMER SERVICES AND EQUIPMENT (CS EQ)

403. Lecture-Demonstration Techniques (3)
413. Home Equipment (3)
450. Problems in Household Equipment (1-6)

INDIVIDUAL AND FAMILY STUDIES (I F S)

416. (C.S. 416) Consumer Role of Family (3)
419. Problems of Family Financial Management (3)
424. Economic Conditions in Relation to the Family (3)
439. Family Resource Management (2)
442. Home Management Experience (3)
477. Analysis of Family Problems (2-9)

FAMILY ECONOMICS AND HOME MANAGEMENT (FE HM)

515. Consumer Problems (2-3) Methods of securing, evaluating, and presenting data concerning household commodities. For home economics teachers in high schools, colleges, and adult classes.

524. Economic Problems of the Household (3) Economic problems of the present-day family; special emphasis on factors in household production, use of money income, and standards of living.

528. Home Management Supervision (2-3) Evaluation of objectives and techniques in organization, supervision, and teaching of the home management house experience.

543. Home Management in Relation to Family Living (3) Includes work with families in solution of their management problems.

544. Problems in Family Economics and Home Management (1-6) Investigation of selected problems in family economics and home management.

550. Seminar in Family Economics and Home Management (1-6) Discussion and reports on developments in family economics and home management.

FOOD SCIENCE (FD SC)

Donald V. Josephson
Chairman of the Division of Food Science and Industry
105 Borland Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Josephson, Keeney, Patton, Watrous, and Adjunct Professor Day; Associate Professors MacNeil, McArdle, McCarthy, Sink, and Adjunct Associate Professor Thompson; Assistant Professor Dimick.
Graduate Faculty, Associate Members: Associate Professor Ziegler, Assistant Professor Kroger.

Opportunities are available for study in the fields of dairy products, meats, fruits

and vegetables, and poultry products. Special emphasis can be devoted to food chemistry, microbiology, quality control, flavor control and acceptance, rheology, processing, packaging, and distribution.

Prerequisite to graduate work is the completion of an undergraduate degree in food technology, biochemistry, microbiology, or other related area. The undergraduate program must have included college mathematics and physics. Students may be admitted with limited deficiency but are required to make up undergraduate deficiencies without degree credit. Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

FOOD SCIENCE (FD SC)

400. Effects of Processing on Foods (3)
402. The Thermal Process (1)
403. Sanitation and Quality Control (3)
410. Chemical Methods of Food Analysis (4)
421. Technical Control Problems (1-6)

505. Concepts of Product Development (3) Interrelationships of processing principles and chemical and physical properties in the development of new and improved food products.

507. Food Quality, Food Standards, and Consumer Protection (2) Problems of the food industry relating to contamination and quality of food products.

510. Seminar in Food Science (1-6)

520. Problems in Food Science (1-9) Special problems in dairy, horticultural, meat, poultry, and other food products.

522. Research Procedures in Food Science (3) Research problems and methods in food science with major emphasis on food chemistry.

In addition to the courses listed above, the following courses are available in food science; their descriptions may be found under the offerings of the cooperating departments: A.I. 421, 431, 502; Ag.E. 412, 413, 414, 423, 503; D.Sc. 427, 521; Hort. 528; Micrb. 414; Pty.Sc. 504.

FOOD SERVICE AND HOUSING ADMINISTRATION (FS HA)

(See Man-Environment Relations)

FOODS AND NUTRITION (F N)

Helen A. Guthrie
In Charge of Graduate Programs in Foods and Nutrition
216 Human Development Building

Degrees Conferred: Ph.D., D.Ed., M.S., and M.Ed. in Foods and Nutrition; M.S. in Nutrition in Public Health.

FOODS AND NUTRITION

Graduate Faculty, Senior Members: Professor Pike, Associate Professor Cox.
Graduate Faculty, Associate Member: Associate Professor Guthrie.

Graduate programs in foods and nutrition prepare students for careers in college teaching, research, and adult program leadership. The program in nutrition in public health prepares the student for work in public health agencies.

For admission to a graduate program in foods and nutrition, a student must have completed at least 9 credits in organic and inorganic chemistry, 3 in biochemistry, 3 in microbiology, 3 in physiology, 4 in other physical and biological sciences, and 8 in foods and nutrition.

For admission to the program in nutrition in public health, the requirements are at least 9 credits in organic and inorganic chemistry, 3 in biochemistry, 3 in microbiology, 12 in social sciences, 7 in foods, and 4 in nutrition.

Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

NUTRITION (NUTR)

400. Special Problems in Foods and Nutrition (1-3)
420. Experimental Cookery (3)
421. Cultural and Aesthetic Aspects of Food (3)
422. Scientific Principles of Food Preparation (3)
452. Nutritional Aspects of Disease (3)
453. Diet Therapy (2)
456. Nutrition in the Community (3)
457. Principles of Nutrition (3)
458. Applied Nutrition (2)
459. Advanced Nutrition (3)
490. Foods and Nutrition Seminar (1)

FOODS AND NUTRITION (F N)

520. Reading in Foods (2) Critical review and reports of literature on selected food topics.

521. Seminar in Foods (1-6) Discussion and reports on current research in the foods field.

522. Advanced Experimental Foods (3) Experimental methods used in measuring the quality of foods; specific problems in food preparation.

530. Problems in Foods and Nutrition (1-6)

550. Readings in Nutrition (3) Readings and reports of selected topics in nutrition.

551. Seminar in Nutrition (1-6) Selected topics and recent advances in nutrition.

552. Nutrition in Disease (3) Physiological and biochemical problems in metabolic diseases and the nutritional aspects of therapy.

555. Field Work in Nutrition (2-4) Field problems planned to meet the needs of individual students. Hours and problems to be arranged.

556. The Survey Method in Foods and Nutrition (2) Study of survey techniques as a tool in the assay of food adequacy and nutritional status.

557. Interrelationships of Nutrients (2) Interrelationships of nutrients in the metabolic processes; their significance as applied to nutrition.

FOREST RESOURCES (FOR R)

Wilber W. Ward
Director of the School of Forest Resources
101 Forestry Building

Degrees Conferred: Ph.D., M.S., M.F.

Graduate Faculty, Senior Members: Professors Fletcher, Sopper, and Ward; Associate Professors George, Gerhold, Hutnik, Murphey, and Shipman.

Graduate Faculty, Associate Members: Adjunct Associate Professor Lindzey, Assistant Professors Beall and Borden.

The graduate programs include two areas of technological inquiry, forest resource management and forest products; and two areas of scientific inquiry, forest science and wood science.

The technological area of forest resource management, which is concerned with planning and operation of the forest land complex, may include specialization in timber management, wildlife habitat management, watershed management, forest recreation, or a combination of all of these land use concepts within the framework of multiple objectives. An undergraduate degree in forest management or a similar program emphasizing biological science, economics, and applied mathematics provides the preparation necessary for these specializations.

The technological area of forest products is concerned with the application of wood technology to the forest products industries with possible specialization in industrial management, quality control, and marketing. An undergraduate degree in wood utilization or a similar program emphasizing mathematics and basic engineering courses is prerequisite.

The forest science area is concerned with those disciplines fundamental to forest management, including forest ecology, wildlife ecology, forest economics, forest entomology, forest genetics, forest hydrology, forest pathology, forest soils, tree physiology, mensuration, and silviculture. An undergraduate degree in forestry or a comparable degree emphasizing mathematics and biological, chemical, and physical sciences is prerequisite.

The wood science area is concerned with the fundamentals of the structural, physical, mechanical, and chemical properties of wood. The student may specialize in wood anatomy, wood moisture relations, wood chemistry, wood adhesion, wood engineering, and pathological and entomological considerations of wood products. An undergraduate degree in wood utilization or its equivalent in mathematics and biological and physical sciences is prerequisite.

For admission applicants should submit a brief statement describing their interests, goals, and special qualifications related to their proposed graduate studies, and should present 9 credits of basic biology; 12 credits of calculus, statistics, or computer science; 12 credits of communications; 12 credits of economics and social sciences, or humanities; and 18 credits in the professional fields served by the School of Forest Resources.

Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

FORESTRY (FOR)

403. Dendrology (3)
410. Forest Resources Seminar (1)
416. Forest Recreation (3)
421. Silviculture (3)
427. Forest Range Management (3)
440. Forest Economics and Finance (3)
450. Advanced Mensuration (3)
455. Forest Photo Interpretation (3)
466. Forest Resource Management (3)
469. (W.S. 469) Problems in Forestry and Wood Science (1-6 per term)
480. Policy and Administration (3)
492. Field and Laboratory Techniques in Wildlife Management in Fall (3)
493. Field and Laboratory Techniques in Wildlife Management in Winter (2)
494. Field and Laboratory Techniques in Wildlife Management in Spring (2)

504. (W.S. 504) Special Topics in Forestry and Wood Utilization (1-6 per term) Problems in forest technology and forest sciences.

508. Advanced Forest Ecology (3) Organization, development, and classification of forest communities. Prerequisite: For. 308.

509. Wildlife Habitat Management (3) Management of forest associations for maintenance and development of wildlife. Prerequisite: For. 508 or Biol. 516.

510. Forestry Seminar (1 per term) Current problems of forest research presented as weekly seminar reports. May be repeated with additional credit for each term's work.

512. Forest Genetics (3) Theoretical and practical application of genetics to forestry; experiments in genetic variation, breeding, progeny testing, and vegetative propagation of trees. Prerequisite: Biol. 22.

517. Forest Microclimatology (3) Forest microclimatology quantitative treatment of climate near the ground, with special reference to the role of forests and terrain. Prerequisite: Phys. 202.

519. Forest Hydrology (3) Influence of forest cover on the disposition of precipitation and the application of hydrologic principles and techniques to forest watersheds. Prerequisites: For. 308, C.E. 51.

521. Advanced Silviculture (3) Specific silvicultural practices for the establishment and manipulation of forest stands with respect to recent developments and research needs. Prerequisite: For. 421.

525. Forest Land Use Alternatives (3) Recognition and analysis of various compatible and conflicting uses of forest land as a component of rural land. Prerequisites: For. 466, Ag.Ec. 421 or Geog. 405, 3 credits in statistics.

550. Design and Analysis of Experiments (3) Specialized techniques involved in the design and analysis of complex forestry research problems. Prerequisite: For. 450.

560. Timber Management (3) Technical methods in the organization and control of the forest property for timber production.

575. Applications of Forest Economics and Finance (3) Survey of situations in forestry where busines problems and particular circumstances of production, value, and costs are currently significant. Prerequisite: For. 440.

WOOD SCIENCE (W S)

411. Physical Properties of Wood (3)
412. Mechanical Properties of Wood (3)
413. Chemical Properties of Wood (3)
420. Processing and Machining of Wood (2)
421. Adhesives and Finishes for Wood Products (2)
422. Seasoning and Preservation (2)
424. Commercial Tropical Woods (3)
430. Forest Products Manufacturing Systems and Standards (3)
437. Wood Micro-Technique (3)
462. Defects in Wood (3)
469. (For. 469) Problems in Forestry and Wood Science (1-6 per term)
491. Logging and Lumbering (3)
495. Forest Products Production Management (3)
497. Small Sawmills (3)

502. Wood Fibers (3) Identification and physical and chemical characteristics of wood fibers used for pulp, either for paper or as a source of cellulose; pulping quality, fiber measurements.

504. (For. 504) Special Topics in Forestry and Wood Utilization (1-6 per term) Problems in forest technology and forest sciences.

510. Wood Utilization Seminar (1 per term)

511. Wood-Fluid Relationships (3) Treatment of adsorption equations, thermodynamics, and diffusion through wood. Prerequisite: W.S. 337.

513. Wood Chemistry (3) Treatment of the chemical components of wood, their distribution and reactions. Prerequisite: W.S. 413.

531. Mechanical Behavior of Wood (3) Time-dependent properties, theory of failure, rheologic properties, and theory of the mechanical behavior of wood and structural composites.

532. Theory of Adhesion (3) Theory of adhesion as it pertains to bonding of wood, paper-based laminates, fibers, and bonding of wood to dissimilar materials.

595. Forest Products Industrial Operation Analysis (3) Applications of operations research methods in the forest products industry; mathematical programming, simulation, waiting line problems, sequencing. Prerequisite: W.S. 495.

FRENCH (FR)

Gérard J. Brault, *Head of the Department*
S-402 Burrowes Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty, Senior Members: Professors Belasco, Brault, Chapman, Eyer, Hyslop, and LeSage.
Graduate Faculty, Associate Member: Assistant Professor Knight.

The minimum requirement for admission to an advanced degree program will normally be 27 credits of post-intermediate work in language and literature. A student may follow a graduate program in French literature and in descriptive and historical linguistics with a minor in a related field. M.A. candidates may submit

either a thesis or a term paper. If the latter is chosen, 6 additional credits in 500-level courses in the major field must be scheduled.

Students who present a 2.50 junior-senior average will be aceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

FRENCH (FR)

417. French Phonology (3)
418. French Morphology and Syntax (3)
422. Old French Literature (3)
426. French Literature of the Renaissance (3)
435-436. 17th Century French Literature (3 each)
445. The French Novel of the Eighteenth Century (3)
446. French Drama of the Eighteenth Century (3)
451-452. 19th Century French Literature (3 each)
460. French Prose of the 20th Century (3)
461. French Poetry and Drama of the 20th Century (3)
470. Advanced Composition and Conversation (3)
480. The Teaching of French (4)
491. Problems in French Literature (3-6)
499. Foreign Study in French (3)

*1G. Elementary French for Graduate Students (3) Designed for students preparing to satisfy language requirements for advanced degrees.

*2G. Elementary French for Graduate Students (3) Continuation of Fr. 1G with reading practice.

500. An Introduction to Old French (3) Analysis of the phonology, morphology, and syntax of the Old French language based on early literary monuments.

503. French Phonology (3) Articulatory and acoustic correlates of distinctive features; synchronic dialectology; phonology in generative grammar.

504. French Morphology and Syntax (3) Principles of segmentation and decomposition; tagmemics and transformation theory; morphophonemics.

505. Semantic Theory of the French Language (3) The goals of semantic description; systematic interrelation of semantic generalizations; empirical and methodological constraints.

516. The Song of Roland (3) Seminar in the Old French *Chanson de Roland,* with emphasis on the problems of textual criticism and literary analysis.

517. Villon (3) The poetry of Villon with reference to the cultural and social context of the late medieval period.

518. Medieval French Drama (3) The development of French drama from its liturgical origins to the flourishing comic theater of the late Middle Ages.

526. Rabelais (3) Seminar in works of François Rabelais, notably Book I (Pantagruel) and Book II (Gargantua), with emphasis on comic devices and narrative technique.

527. French Renaissance Poetry (3-6) Evaluation of French poetry from Marot through the Pléiade; emphasis on Ronsard and DuBellay.

* No graduate credit is given for this course.

528. Montaigne (3) Genesis and evolution of Montaigne's creation of the personal essay; influence of the *Essais* in 17th, 18th century French literature.

533. Seventeenth Century Prose and Poetry (3) The development of Classicism; its apogee and decline as seen in the works of major prose writers and poets.

534. Moliere (3) The literary achievement of Molière, the comic playwright, director, actor, and founder of the Comédie Française.

535. Seventeenth Century French Tragedy (3) The development and triumph of tragedy as a literary genre with special emphasis on the achievement of Corneille and Racine.

536. La Fontaine (3) The literary artistry of La Fontaine with special emphasis on his contribution as a fabulist.

540. Voltaire (3) The artistic and philosophical evolution of Voltaire as seen in the tragedy, the philosophical tale, and poetry.

541. Rousseau (3) Rousseau's rationalistic critique of civilization; his sentimental rehabilitation of the individual, family, state; Rousseau precursor of Romanticism.

542. Diderot and the Encyclopedists (3) The literary *philosophe* in the Age of Enlightenment with special emphasis on Diderot and his collaborators on the *Encyclopédie.*

561. French Romanticism (3) The Romantic movement in French literature with emphasis upon its major exponents in prose and poetry.

563. French Realism (3) The Realistic movement in French literature with emphasis upon its major exponents in prose and poetry.

565. The Nineteenth Century French Novel (3) The development of the novel in the 19th century with emphasis on Constant, Balzac, Stendhal, Flaubert, and Zola.

567. Twentieth Century French Theatre (3) Evolution of the French theatre from the plays of the *belle époque* to the avant-garde works of today.

568. Baudelaire (3) A study of his poetry and his criticism.

569. Masters of 20th Century French Literature (3-6) Major literary figures of contemporary French literature.

571. French Literary Criticism from Sainte-Beuve to Present (3) Evolution of French literary criticism from Sainte-Beuve, the "father" of modern literary criticism, to contemporary critics.

581. Theory and Techniques of Teaching French (1-3)

595. Analysis of French Civilization (3-6) French cultural aspects, other than language and literature, conducted in French with the collaboration of specialists outside the French department.

596. Symbolism (3) The anti-positivistic tradition in 19th century French literature dealing with the Symbolist School; its antecedents and its subsequent ramifications.

597. Research Techniques and Bibliography in French Language and Literature (1-3)

598. Seminar in French Literature (3-12) Lectures on methods of research. Students will pursue common and individual investigations in fields selected after consultation with the instructor.

FUEL SCIENCE (F SC)

HOWARD B. PALMER
In Charge of Graduate Programs in Fuel Science
322 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Austin, Essenhigh, Given, Palmer, and Walker; Associate Professor Vastola; Assistant Professor Polansky.

Graduate Faculty, Associate Members: Assistant Professors Becker and Roscoe.

This program is one of the options in which a graduate student in the Department of Materials Science can receive an advanced degree.

Research facilities, well instrumented, are available for the study of high temperature gas reactions by shock-tube and other techniques, electrochemical kinetics of fuel cell and battery systems, reactions in plasmas and flames, physics and chemistry of carbons and graphites, fundamental processes in the industrial combustion of gaseous, liquid, and solid fuels, mass spectrometric investigation of the structure of solids, comminution of brittle materials, and the organic geochemistry of plant-derived sediments. Students can plan a wide variety of programs of study, to suit individual needs; coherent interdisciplinary programs are encouraged. The no-thesis option is available for the M.S. degree.

Applications will be accepted from persons having backgrounds in chemistry or physics; chemical, mechanical, or aerospace engineering; materials sciences; or earth sciences. Students having at least a 2.50 junior-senior average and appropriate supporting information will normally be admitted subject to the limitations of facilities. Exceptions to these requirements may be made for students with special backgrounds, abilities, and interests.

A basic minimum of 30 course credits is required for the Ph.D. degree, of which at least 12 must be in departmental courses.

FUEL SCIENCE (F SC)

400. FUEL SCIENCE RESEARCH AND DESIGN (1-10 per term)
410. FUEL SCIENCE LABORATORY (1) *Mr. Polansky and Staff*
421. FLAMES (3)
422. COMBUSTION ENGINEERING (3)
423. COMBUSTION LABORATORY (1)
424. ENERGY IN SPACE TRAVEL (3)
431. THE CHEMISTRY OF FUELS (3)

504. (Gchem. 504) ORGANIC GEOCHEMISTRY OF COAL (3) Interdisciplinary study of accumulation of organic sediments and their metamorphism into coal macerals; effects of environment; structure of coal macerals.

506. KINETICS OF CARBON REACTIONS (3) Current approaches to heterogeneous reactions in combustion and gasification of coals and carbons. Prerequisite: Chem. 451. *Mr. Walker*

510. SPECIAL TOPICS IN FUEL SCIENCE (1-6 per term)

511. FUEL SCIENCE SEMINAR (1 per term) Selected topics from current research relevant to fuel science.

512. HIGH TEMPERATURE KINETICS AND FLAME PROPAGATION (3) Laminar and turbulent premixed and diffusion flames; gaseous detonations; rate processes in high temperature gases. Prerequisite: F.Sc. 421. *Mr. Palmer*

514. Jet and Rocket Fuels (2) Propulsion systems; combustion chamber conditions; liquid and solid propellants, slurries, fuel sprays, and finely divided solids. Prerequisite: F.Sc. 421. *Mr. Palmer*

515. Catalysis of Fuel Reactions (2) Principles of chemisorption and catalysis; mechanisms of specific catalytic reactions and practical aspects of catalytic processes in the fuels industries. Prerequisite: Chem. 452. *Mr. Roscoe*

Note: *Courses in the use of X-ray diffraction, electron microscopy, spectroscopy, and electronic instrumentation in fuel science studies are listed under Materials Science.*

GENERAL ENGINEERING (GEN E)

Otis E. Lancaster
Chairman of the Committee on General Engineering
101 Hammond Building

Degrees Conferred: M.Ed., M.Eng.

This program is designed primarily to meet the needs of the engineering faculty in the various technical institutes. The objective is to give academic preparation to those individuals who will teach engineering subjects at the two-year college level.

For admission an undergraduate degree in engineering, physical science, mathematics, or the equivalent is required. Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

For either degree a minimum of 30 credits is required in addition to a scholarly written report. Twenty-four of these credits should be in engineering, physics, and mathematics. A candidate is expected to earn at least 3 credits each in mathematics, physics, and two fields of engineering, or demonstrate competence in them.

For the M.Ed. 6 credits must be in education, consisting of one 3-credit course in the theory of learning and teaching and one 3-credit course in internship in college teaching. Fifteen credits must be earned at the 500 level.

For the M.Eng. degree 6 credits may be taken in any field approved by the committee, but at least 12 credits in engineering subjects must be at the 500 level.

GENERAL FAMILY STUDIES (G F S)

Addreen Nichols
In Charge of Graduate Programs in General Family Studies
S-255 Human Development Building

Degrees Conferred: M.S., M.Ed.

Because this program is planned for teachers in secondary schools or small colleges and others who wish to become proficient in several areas of home economics, the student must have a strong home economics background for admission.

The major for the M.S. or M.Ed. degree consists of a minimum of 6 credits in each of three areas of home economics. The student chooses a minor field of educational foundations or, if sufficient competence in educational foundations is demonstrated, one of the applied fields, such as home economics education, secondary education, or higher education.

Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

GENETICS (GENET)

EDWARD G. BUSS, *Chairman of the Committee on Genetics*
203 Animal Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Buss, Dalton, Ginoza, Goodwin, Grun, O'Mara, R. Nelson, Person, Starling, Vesell, Walker, Wright, and Zimmerman; Associate Professors Cleveland, Creech, Gerhold, Hicks, and Adjunct Associate Professor Marshall; Assistant Professor Todd.

Graduate Faculty, Associate Members: Associate Professors M. W. Johnson and Pfeiffer; Assistant Professors Costantino, Craig, Lennox, and Adjunct Assistant Professor Hill.

Graduate programs are offered in the fields of theoretical and applied genetics, including plant and animal breeding. Courses in genetics and breeding are given by various departments. Basic and theoretical courses are offered in the Departments of Biology and Biophysics; courses dealing with genetic principles applied to specific organisms are offered in the Departments of Agronomy, Animal Science, Dairy Science, Forest Management, Horticulture, Microbiology, and Poultry Science. The graduate committee for majors shall be appropriately represented by members of theoretical and applied phases who have the responsibility and jurisdiction for determining course work, language requirements, and research acceptable in satisfying degree requirements.

For entry as a major in this field no fewer than 15 credits in basic biology and 15 credits in the areas of chemistry, mathematics, and physics are required.

Students who present a 2.80 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

The following courses are available in genetics or breeding, and their descriptions may be found under the offerings of the several departments: Agro. 411, 509, 510, 582; A.I. 505; An.Sc. 422; Biol. 405, 422, 428, 430, 501, 505, 524, 525, 528, 533; Bphys. 430, 582, 589; D.Sc. 513; For. 512; Hort. 407, 444, 501, 520, 524; Micrb. 516; Pharm. 540; Pty.Sc. 402, 505.

GEOCHEMISTRY (GCHEM)

ARNULF MUAN
Head of the Department of Geochemistry and Mineralogy
204 Deike Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Barnes, Bates, Brindley, Burnham, Greig, Griffiths, Keith, Muan, Osborn, Roy, and Wickman; Associate Professors Dachille, Newnham, Smith, Thornton, and White; Mrs. Roy.

Graduate Faculty, Associate Members: Associate Professor Rose; Assistant Professors Boettcher, Deines, Langmuir, and Suhr.

Areas of specialization include crystal chemistry, phase equilibria, element distribution and affiliations, isotope geochemistry, geochemical prospecting, cosmochemistry, high-temperature and high-pressure geochemistry, and solid state technology.

Before starting graduate study, an applicant is generally expected to have had a standard introductory course in each of the following four subjects—chemistry, physics, geology, and mineralogy; 12 credits of intermediate-level work in any one or a combination of chemistry, physics, and geological science; and mathematics through integral calculus.

Students who present a 2.70 average in their basic science and geoscience subjects will be considered by the department subject to the limitations of the facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

The no-thesis option is available for the M.S. degree.

Students who have taken somewhat less than the indicated minimum of subjects may be admitted but must make up their deficiencies concurrently with their graduate studies.

GEOCHEMISTRY (GCHEM)

402. Introduction to Organic Geochemistry (3)
457. Geochemical Prospecting (2) *Mr. Rose*
471. (Geol. 471) Field Studies in North America (3)

501. Research (1-10 per term) Research in geochemistry.

504. (F.Sc. 504) Organic Geochemistry of Coal (3) Interdisciplinary study of accumulation of organic sediments and their metamorphism into coal macerals; effects of environment; structure of coal macerals.

509. Geochemistry Seminar (1 per term)

510. Problems in Geochemistry (1-9) Laboratory and library study of special problems.

512. (Mat.Sc. 512) Principles of Crystal Chemistry (2-4) Relation of structure to ionic size and nature; influence of pressure and temperature on structure; chemical-structural defects, crystalline solutions, phase-transitions. *Mr. Roy*

513. Phase Equilibria in Mineral Systems at High Temperatures (2-4) Interpretation of phase diagrams with emphasis on high-temperature oxide systems at atmospheric pressure; measurement of p-t-x, determination of equilibrium diagrams. *Mr. Muan*

514. Element Distribution in the Earth (3) Principles and data from studies of phase equilibria, petrology, and crystal structure as related to distribution of elements in minerals, rocks, and the earth. *Mr. Wickman*

517. Age Determinations (1-2) Geochemistry of radioactive elements and their daughters; age determination techniques and observations. *Mr. Deines*

518. Stable Isotope Geochemistry (3) Theory of isotope fractionation mechanisms; its application to a wide range of problems in the earth and planetary sciences. *Mr. Deines*

519. Cosmochemistry and Nucleogenesis (2) Distribution and composition of matter; origin of solar system and earth, of constituent nuclides, of life.

520. P-T-X Phase Equilibria (3) Phase equilibrium in mineral systems with pressure as a variable. Prerequisite: Gchem. 513. *Mr. Boettcher*

GEOCHEMISTRY

522. Geochemistry of Aqueous Systems (3) Ionic and molecular equilibria related to stabilities and solubilities of minerals: Eh-pH, Po_2-pH relations applied to ground water, sea water, hydrothermal fluids. *Messrs. Barnes and Schmalz*

523. Water-Resource Geochemistry (2-4) Topics and problems concerning the chemical quality of surface waters and ground waters related to hydrogeologic and cultural controls. *Mr. Langmuir*

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in geochemical studies are listed under Materials Science.*

GEOGRAPHY (GEOG)

Allan L. Rodgers, *Head of the Department*
403 Deike Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors Brookfield, Deasy, Gould, Lewis, Miller, Rodgers, Wernstedt, and Zelinsky; Associate Professor Simkins.

Graduate Faculty, Associate Members: Assistant Professors Adams and Williams.

The student may concentrate on economic geography, cultural geography, physical geography, one of the major world regions, or acceptable combinations of these fields. In addition, all students receive training in cartographic, statistical, and bibliographic techniques.

Because physical geography is a branch of the physical sciences, and cultural and economic geography are branches of the social sciences, a student may enter graduate work under either of two options. Option 1, for the student who wishes to specialize in physical geography, requires the completion of 18 undergraduate credits in geography and 20 credits in mathematics and biological and physical sciences, including at least 6 credits in geology. Option 2, for the student who wishes to specialize in cultural or economic geography, requires 18 undergraduate credits in geography plus 20 credits in the social sciences, including at least 6 in economics.

Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

GEOGRAPHY (GEOG)

401. Historical Geography of North America (3) *Mr. Zelinsky*
402. Cultural and Anthro-Geography (3) *Mr. Zelinsky*
405. Geography of Population (3) *Mr. Zelinsky or Mr. Simkins*
407. Geography of Settlement (3) *Mr. Brookfield or Mr. Williams*
410. Cartography—Map Design and Construction (3) *Mr. Deasy*
420. Urban Geography (3) *Mr. Adams*
427. Geography of the Soviet Union (3) *Mr. Rodgers*
428. Geography of Eastern Europe (3)
430. Agricultural Geography (3)
433. Regional Climatology (3) *Mr. Wernstedt*
434. Regional Physiography (3) *Mr. Lewis*
440. Geography of Middle America (3) *Mr. Simkins*
441. Geography of South America (3) *Mr. Simkins*

442. Regional Systems in Europe (3) *Mr. Miller*
443. Geography of the Orient (3)
444. Geography of Africa (3) *Mr. Brookfield*
445. Geography of Southern Asia (3) *Mr. Wernstedt*
446. Regional Geography of North America (3) *Mr. Deasy*
450. Development of Geographic Thought (3) *Mr. Abler*
451. Map Interpretation (3) *Mr. Lewis*
452. Interpretation of Aerial Photographs (3) *Mr. Deasy*
456. Quantitative Methods of Geographical Analysis (3) *Mr. Gould, Mr. Williams, or Mr. Strack*
460. Political Geography (3) *Mr. Lewis*
468. Geography of Transportation and Communications (3) *Mr. Gould*
470. Industrial Location and Development (3) *Mr. Rodgers*
475. Geography of Communications Systems (3) *Mr. Abler*
480. Manufactural Systems Analysis (3) *Mr. Miller*
490. Physical Geography for Teachers: Landforms (3) *Mr. Lewis*
491. Physical Geography for Teachers: Regional Climatology (3) *Mr. Wernstedt*
497. Directed Readings (1-9) *Staff*
498. Problems in Geography (3) *Staff*

500. Introduction to Geographic Research (3)

501. Geographic Bibliography (1) An introduction to the techniques of bibliographic search and the writing of research papers in geography. Prerequisite: Geog. 500.

503. Advanced Regional Geography (3-12) Intensive study at an advanced level of selected regions or sections of the continents. Prerequisite: 12 credits in geography.

504. Physical Geography Seminar (3-12) The examination of current problems and theories in physical geography through critical discussion of the literature and student research.

505. Economic Geography Seminar (3-12) The examination of current problems and theories in economic geography through critical discussion of the literature and original student research.

506. Political Geography Seminar (3-6) The exploration of current problems and theory in political geography through critical discussion of the literature and original student research. Prerequisite: Geog. 460.

508. Cultural Geography Seminar (3-6) The exploration of current problems and theory in cultural geography through critical discussion of the literature and original student research.

509. Population Geography Seminar (3) Selected problems in population geography with emphasis on analysis and presentation of data. Prerequisite: Geog. 405.

510. Physical Geography Research (3-10) Directed study in physical geography focusing on theory, analytical methods, or a selected problem.

511. Economic Geographic Research (3-10) Directed study in economic geography focusing on locational theory, analytical methods, or a selected problem.

512. Cultural and Political Geography Research (3-10) Directed study in cultural or political geography focusing on theory, analytical methods, or a selected problem.

520. Metropolitan Analysis (3) Land use models, urban factorial ecology; intraurban movements; urban renewal, ghetto structure, residential change; commercial structure, blight. Prerequisite: Geog. 420 or 456.

543. Conceptual Frameworks for Geographical Analysis (3) Critical analysis of structures of inquiry in geography: modeling, problems of causation, measurement, and ordering of spatial information.

567. Applied Quantitative Methods (3) Simulation, topological, queuing, programming, factor analytic, discriminant, and game theoretic models applied to geographic problems of spatial diffusion and interaction. Prerequisite: Geog. 456.

GEOLOGY (GEOL)

Lauren A. Wright
Head of the Department of Geology and Geophysics
303 Deike Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Ridge, Scholten, Spackman, Williams, and Wright; Associate Professors Dutcher, Parizek, Schmalz, Traverse, and Weber; Assistant Professor Voight.

Graduate Faculty, Associate Members: Associate Professors Gold, Assistant Professors Cuffey and Guber.

Programs are offered in stratigraphy, paleontology, sedimentation, paleobotany, palynology, regional and structural geology, geomorphology, ground water geology, engineering geology, marine geology and chemical oceanography, coal geology, coal petrology, and geology of metallic and nonmetallic deposits. For admission 25 credits in chemistry, physics, mathematics, and biological sciences, and at least 18 in geology and mineralogy are required.

Students who have taken somewhat less than the indicated minimum in these subjects may be admitted but must make up their deficiencies concurrently with their graduate studies.

Students may be accepted with a previous degree in geophysics, physics, mathematics, engineering, earth sciences, or a closely allied field. Students whose grade point average in courses pertinent to geology is below 3.00 will be admitted only when there are strong indications that this average can be maintained at the University. Exceptions to these requirements may be made for students with special backgrounds, abilities, and interests.

GEOLOGY (GEOL)

400.	Surface Geological Processes for Teachers (3)	*Mr. Weber*
401.	Earth History for Teachers (3)	*Mr. Cuffey*
402.	Field Methods for Teachers (3)	*Mr. Wright*
410.	Structural Geology (3)	*Mr. Gold*
420.	(Biol. 420) Paleobotany (3)	*Mr. Spackman*
421.	Introduction to Coal Petrology (3)	*Messrs. Dutcher and Spackman*
423.	(Biol. 423) Introductory Palynology (3)	*Mr. Traverse*
430.	Paleontology (3)	*Mr. Guber*
440.	Marine Geology (3)	*Mr. Schmalz*
451.	Economic Geology (3)	*Mr. Ridge*
452.	Introduction to Hydrogeology (3)	*Messrs. Langmuir and Parizek*
453.	Mechanics of Geological Materials (3)	*Mr. Voight*

461. Geology of North America (3) *Mr. Wright*
462. Principles of Geomorphology (3-6) *Mr. Lattman*
470. Introduction to Field Geology (3) *Mr. Wright*
471. (Gchem. 471) Field Studies in North America (3)
472. Field Geology (5) *Mr. Dutcher*
481. Geology of Oil and Gas (3) *Mr. Scholten*
490. Stratigraphy (4) *Mr. Williams*

*500. Geology Seminar (1-9) Presentation, at weekly departmental meetings, of topics selected from geological literature. *Messrs. Guber and Williams*

†501. Stratigraphy (3-12) Principles of stratigraphic classification, lithofacies and biofacies, faunal zonation, correlation, sedimentation, and paleogeography, illustrated by stratigraphy of classical geologic regions: (a) Pre-Cambrian; (b) Paleozoic; (c) Mesozoic; (d) Cenozoic. Prerequisite: Geol. 430. *Mr. Williams*

†503. Paleontology (3-9) Morphology of animal groups significant for their fossils; nature of species and faunal zones. Seminars may be arranged for studies of special fossil groups, microfossils, paleoecology. *Mr. Cuffey*

504. History and Foundations of Geology (2-4) Theoretical aspects of geology; spatio-temporal organization of matter, dynamic processes, sequential development; basic patterns and history of scientific thought. *Mr. Williams*

507. Seminar in Geomorphology (3-6) Classic and current literature in geomorphology. *Mr. Lattman*

511. Ore Deposits: Principles (3-6) Geological and geochemical processes controlling ore deposition; genetic classification of ore deposits. Prerequisite: Geol. 451. *Mr. Ridge*

512. Ore Deposits: Types (1-6) Geologic history and field examination of selected ore bodies; forming media; causes, sequences, and loci of emplacement; wall rock alteration; secondary enrichment. Prerequisite: Geol. 511. *Mr. Ridge*

515. Ore Microscopy (2-3) Theory and use of the ore microscope in identifying ore minerals in polished section, establishing paragenetic sequences, determining manner of deposition. *Mr. Barnes*

‡517. Sediments of the World (2-6) Evolution of sediments from Archean to Recent; relationship of sedimentation to geotectonism; kratonic and geosynclinal sediments; cyclicity. Prerequisites: Min. 512, 514. *Messrs. Scholten and Williams*

524. Coal Petrology (1-6) Microscopy, source materials, coalification, constitution, classification of peats, lignites, bituminous coal, anthracite.
Messrs. Dutcher and Spackman

526. (Biol. 526) Problems in Palynology (1-6) Systematics; paleoecological palynology; Paleozoic palynology; Mesozoic and Cenozoic palynology; Pleistocene vegetational history. *Mr. Traverse*

530. Geological Problems (1-15) Prerequisite: 10 credits in geology and mineralogy.

540. Chemical Oceanography (3) Chemical reactions in sea water and at the sea floor related to sedimentation and diagenesis. *Mr. Schmalz*

545. Glacial Geology (3) Glaciers: their characteristics, causes, deposits, landforms, effects in periglacial regions. *Mr. Parizek*

* Credits to be arranged, 1 to 6 per term.
† Credits to be arranged, 3 to 6 per term.
‡ Credits to be arranged, 2-3 per term.

546. Principles of Photogeology (3) Use of aerial photographs and mosaics in structural, geomorphic, and rock distribution studies and in compilation of maps. Prerequisites: Geol. 410, 462. *Mr. Lattman*

551. Dynamic Structural Geology and Geotectonics (3-6) Phenomena of fracturing, faulting, folding; stress and (finite) strain analysis, physical and analytical models; deformational environments; tectogenesis and orogenesis. *Mr. Scholten*

555. Advanced Structure and Petrofabrics (1-3) Macroscopic and microscopic recognition, measurement, and interpretation of small-scale rock structures and mineral orientation patterns in deformed rocks. *Mr. Gold*

571. Habitat of Oil (3) Geologic setting of petroleum as determined by basin tectonism, sedimentation, hydraulic and capillary forces, and reservoir textures. *Mr. Scholten*

590. Geology Field Trip (1 per year) Field study of regional geologic features with trips in successive years to differing geologic provinces.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in geological studies are listed under Materials Science and Mineralogy.*

GEOPHYSICS (GPHYS)

Lauren A. Wright
Head of the Department of Geology and Geophysics
303 Deike Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Bell and Howell.

Graduate Faculty, Associate Members: Associate Professor Alexander, Assistant Professors Greenfield and Lavin.

Students may specialize in seismology, physical properties of rocks, geophysical surveying, geomagnetism, geo-electricity, gravity, wave propagation, time-series analysis, space applications of geophysics, tectonics, earth physics, and planetary sciences.

For admission an applicant is generally expected to have had mathematics through differential equations; a standard introductory course each in physics, chemistry, and earth sciences; and at least 16 credits of intermediate-level work in any one or a combination of these subjects.

Applicants who have taken somewhat less than the indicated minimum in these subjects may be admitted but must make up their deficiencies concurrently with their graduate studies.

Students may be accepted with a previous degree in geophysics, physics, mathematics, engineering, earth sciences, or a closely allied field. Students whose grade point average in courses pertinent to geophysics is below 3.00 will be admitted only when there are strong indications that a 3.00 average can be maintained at the University. Exceptions to these requirements may be made for students with special backgrounds, abilities, and interests.

The no-thesis option is available for the M.S. degree.

GEOPHYSICS (GPHYS)

400. Physics of the Earth for Teachers (3) *Mr. Lavin*

406. Physics of the Earth (3) *Mr. Lavin*
407. Well Logging (3)
408. Geophysical Surveying (3) *Mr. Lavin*
415. Gravity and Magnetic Surveying (3) *Mr. Lavin*
416. Electrical Surveying (3) *Mr. Greenfield*
417. Seismic Methods (3) *Mr. Lavin*
418. Potential Theory Applied to Earth Problems (3) *Mr. Alexander*

500. Geophysical Seminar (1 per term) Dicussion of geophysical reports and papers; scientific outlook.

501. Research (1-10 per term) Research in geophysics.

502. Seismic Instruments (3) Characteristics and design of seismometers and seismic recorders. *Mr. Howell*

503. Special Studies in Geophysics (1-9) Special studies of the theories of geophysical methods.

504. Communication Theory for Geophysicists (3) Basic theory of random processes leading to and including optimum filters; geophysical applications to gravity and seismic data analysis.

507. Seismology (3) Nature and transmission of seismic waves; cause and occurrence of earthquakes; applications in seismic prospecting. *Mr. Alexander*

508. Tectonics (3) Seminar in the cause and nature of the principal deformations of the earth.

516. Introduction to Nuclear Processes in Geologic Settings (2) Natural radioactivity and its measurement, interpretation, and use in research and exploration.

521. Thermal State of the Earth (2) Methods and instrumentation of geothermal measurements; geothermal observations; development of the theory of the thermal state of the earth.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in geophysical studies are listed under Materials Science and Mineralogy.*

GERMAN (GER)

Stanley R. Townsend, *Head of the Department*
S-323 Burrowes Building

Degrees Conferred: Ph.D., M.A., M.Ed.

Graduate Faculty, Senior Members: Professors Ebbinghaus, Shelley, Strelka, and Townsend; Associate Professor Preisner.

Graduate Faculty, Associate Members: Professor de Levie, Associate Professor Timpe, Assistant Professor Kopp.

There is opportunity for major emphasis upon either literature or philology. Minimum qualifications for admission include 24 undergraduate credits in German beyond the intermediate level; provision is made, however, for admission with limited deficiencies. Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the

limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

Students may qualify for the M.A. and M.Ed. degrees either by writing a thesis—which is recommended if a student wishes to be considered for Ph.D. candidacy—or by submitting an essay to the department and taking additional 500-level German courses in lieu of 6 credits of thesis research.

GERMAN (GER)

401. Advanced Stylistics (3)
411. The Teaching of German (3)
430. History of the German Language (3)
443. (C.Lit. 443) Literary Relations of Germany with England and America (3-9)
454. Literature from the Age of Chivalry to the Thirty Years' War (3)
464. Literature from the Beginning of the Enlightenment Through Storm and Stress (3)
469. Goethe's Life and Works (3)
474. Classicism and Romanticism (3)
484. Literature from Realism to Expressionism (3)

*1G. Elementary German for Graduate Students (3) Designed for students preparing to satisfy language requirements for advanced degrees.

*2G. Elementary German for Graduate Students (3) Continuation of Ger. 1G with opportunity for reading in special fields.

500. Bibliography and Research Techniques (3) Introduction to tools and methods of research, designed for students preparing for independent investigation of problems in German literature and language.

520. Introduction to Middle High German (3) Descriptive and historical grammar; readings in simple Middle High German texts.

521. Readings in Middle High German (3) Intensive reading in Middle High German literature, especially of the *Blütezeit*. Prerequisite: Ger. 520.

522. Old High German (3) Essentials of the grammar with special treatment of the High German sound shift and of ablaut and umlaut; reading of works written before 1100 A.D.

523. Gothic (3) Introduction to the historical and comparative Germanic grammar; emphasis on the Gothic language and texts. Suitable for advanced students in English.

525. Old Icelandic (3) Introduction to Old Icelandic grammar; readings in Old Icelandic prose. Suitable for advanced students in English.

531. Seminar in Medieval German Languages and Literatures (3-6)

541. Seminar in the Literature of the Reformation and Baroque (3-6)

551. Seminar in the Literature of the Enlightenment and the Age of Goethe and Schiller (3-6)

561. Seminar in Post-Idealistic Literature (3-6)

571. Seminar in Modern German Literature (3-6)

* No graduate credit is given for this course.

581. Seminar in Literary Genres (3-12) Special studies in the German lyric, drama, short story, and novel.

591. Seminar in German Literary Criticism (3)

HIGHER EDUCATION (HI ED)

Hans Flexner
In Charge of Graduate Programs in Higher Education
206 Education Building

Degrees Conferred: D.Ed., M.Ed.

Graduate Faculty, Senior Members: Professors Anderson, Lutz, Sweitzer, Willower, and Yamamoto.
Graduate Faculty, Associate Members: Professor Godbey, Associate Professors Flexner and Lindsay.

The Pennsylvania State University Graduate School maintains a graduate curriculum in higher education for those who are interested in post-secondary instruction, administration, and research in higher education as areas of study and inquiry. The curriculum is managed through the College of Education, Division of Education Policy Studies, and includes both a minor in college teaching and a major in general higher education. The minor program is administered through the students' major departments outside of education. This leaves a small number of selected students who will be admitted to advanced study with higher education as a major.

Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

For admission to the higher education major, students are expected to meet the general requirements of the Graduate School; for special requirements in higher education, write: **HIGHER EDUCATION, 206 Education Building,** The Pennsylvania State University, University Park, Pennsylvania 16802.

HIGHER EDUCATION (HI ED)

545. Higher Education in the United States (2-3) A basis for all courses in higher education. Current issues are analyzed and trends of the future anticipated.

546. The Principles of College Teaching (2-3) Principles involved in teaching at the college level; effective use of teaching aids; criteria used in evaluation.

547. Internship in Higher Education (1-9) Supervised experience in administrative offices, in research, on instructional teams, and in college teaching.

548. Curriculums in Higher Education (2-3) Various types of curriculums and philosophies underlying them; ways in which curriculums are developed; elective versus required courses; evaluation of achievement.

549. Community Junior College and the Technical Institute (2-3) Distinctive contributions to meeting the need for post-secondary education; development, functions, curriculum and instruction, government, administration and finance.

550. The Professions and the Education of Teachers (3) The nature of a profession and dimensions of professional education in the United States are explored. Trends and issues examined.

552. Administration in Higher Education (2-3) Philosophy of administration; principles of scientific management and their application in colleges and universities; case studies of administrative problems. Prerequisite: courses or experience in higher education.

554. The History of American Higher Education (3) An examination of the development of American higher education against the background of influential social, political, economic, and intellectual issues.

555. Seminar in Higher Education (1-6) Special topics in higher education.

HISTORY (HIST)

Kent Forster, *Acting Head of the Department*
116 Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty, Senior Members: Professors Brown, Dahmus, Forster, Hassler, Klein, McNall, and Murray; Associate Professors Eggert and Sun.

Graduate Faculty, Associate Members: Professor Green; Associate Professors Ameringer, Frantz, Linker, Maddox, Meier, and Pixton; Assistant Professors Borza, Enteen, Goldschmidt, and Silverman.

Graduate work is offered in the following areas of history: ancient, medieval, Europe since 1500, Great Britain and the British Empire, Russia and Eastern Europe, the Middle East, the Far East, the United States, and Latin America. These areas are subdivided into chronological, national, and topical fields.

The candidate for the M.A. or M.Ed. degree selects one of the above areas for his master's examination. He must take some courses in an area in history other than his examination area and in a cognate field. (The cognate field for an M.Ed. candidate must be in education). With the consent of his adviser, a master's candidate may substitute additional course work and a paper for a thesis.

The candidate for the doctor's degree must pass examinations in one of the above areas, in a thesis field within that same area, and in one field from a second area. He must also pass an examination in a single cognate field, or in a study area made up of a number of academic disciplines related to the subject of his thesis. The Ph.D. candidate must have a reading knowledge of two foreign languages or one language and work in quantitative techniques. The D.Ed. candidate has no foreign language requirement; however, he must minor in education.

All students are advised that individual instructors may require a reading knowledge of pertinent languages for seminar work and for research on thesis topics.

The entering student should present evidence of undergraduate course work covering the history of Europe from ancient times to the present and the history of America from its discovery to the present. The department ordinarily requires better than a 3.00 average in all undergraduate history courses and a 3.00 junior-senior average. Each applicant must provide Graduate Record Examination scores and at least two letters of recommendation. Exceptions to these requirements may be made for students with special backgrounds, abilities, and interests.

HISTORY (HIST)

401. Classical Civilization (3) *Messrs. Borza and Gregory*
403. The Middle Ages from Constantine to the Crusades (3) *Mr. Dahmus*
404. The Middle Ages from the Crusades to the Renaissance (3) *Mr. Dahmus*

408. Intellectual History of the Middle Ages (3) *Mr. Dahmus*
410. The Renaissance (3) *Mr. Spielvogel*
411. The Reformation (3) *Mr. Spielvogel*
413. The Age of Absolutism (3) *Mr. Green*
414. The French Revolution and the Napoleonic Era (3) *Mr. Green*
417. Nineteenth Century Europe (3) *Mrs. Rosenblatt*
419. Recent European History (3) *Mr. Forster*
422. History of the American Frontier (3) *Mr. McNall*
425. History of American Political Parties (3) *Mr. Stein*
426. The Diplomatic History of the United States to 1900 (3) *Mr. Maddox*
427. The Diplomatic History of the United States Since 1900 (3) *Mr. Maddox*
428. American Military History (3) *Mr. Hassler*
430. Colonial America to 1753 (3) *Mr. Frantz*
431. Revolutionary America, 1753-1783 (3) *Mr. Frantz*
432. The Formative Period of American History (3) *Mr. Brown*
433. The Middle Period of American History (3) *Mr. Klein*
434. The United States in Civil War and Reconstruction (3) *Mr. Hassler*
435. The Emergence of Modern America (3) *Messrs. Murray and Stein*
436. Recent American History (3) *Mr. Murray*
439. History of England in the Middle Ages (3) *Mr. Dahmus*
440. Britain Under the Tudors and Stuarts, 1485-1688 (3) *Mr. Linker*
441. Great Britain, 1688-1832 (3) *Mr. Linker*
442. History of Russia to 1801 (3)
443. History of Russia, 1801-1917 (3)
444. Eastern Europe in Modern Times (3) *Mr. Enteen*
447. Social and Economic History of Europe Since 1750 (3) *Mr. Silverman*
448. Intellectual and Cultural History of Modern Europe (3) *Mrs. Knight and Mr. Silverman*
449. Diplomatic History of Europe Since 1870 (3) *Mr. Forster*
452. Social and Cultural History of the United States Since 1783 (3) *Mr. Brown*
453. American Economic History in the Agricultural Era (3) *Mr. McNall*
454. American Economic History in the Industrial Era (3) *Mr. Eggert*
456. (L.M.R. 456) History of American Labor (3) *Mr. Eggert*
458. Constitutional History of the United States to 1877 (3) *Mr. Stebbins*
459. Constitutional History of the United States Since 1877 (3) *Mr. Stebbins*
460. Latin America and the United States (3) *Mr. Ameringer*
461. Social and Cultural History of Latin America (3) *Mr. Garner*
462. Mexico and the Caribbean Nations in the 20th Century (3) *Mr. Ameringer*
467. Alexander the Great and the Hellenistic World (3) *Mr. Borza*
468. The Roman Republic (3) *Messrs. Borza and Gregory*
469. The Pax Romana (3) *Mr. Gregory*
471. Nineteenth Century China (3) *Mrs. Sun*
472. Twentieth Century China (3) *Mr. Duiker*
479. Modern Vietnam, Laos, and Cambodia (3) *Mr. Duiker*
480. The Medieval Middle East, 600-1800 (3) *Mr. Goldschmidt*
481. The Middle East in Modern Times (3) *Mr. Goldschmidt*
491. History of the Soviet Union (3) *Mr. Enteen*
492. Great Britain Since 1832 (3) *Mr. Linker*
497. Germany Since 1640 (3) *Mr. Silverman*
498. Selected Topics in History (3-6)

501. Historical Method (3) *Mr. Meier*

502. Historiography (3) *Mr. Meier*

503. Studies in Medieval English History (3-6) A seminar in the political, economic, and cultural history of England in the Middle Ages. *Mr. Dahmus*

504. Medieval Civilization (3-9) *Mr. Dahmus*

505. The Age of the Reformation (3-6)

507. Studies in European History, 1600-1750 (3-6) *Mr. Green*

508. Studies in European History, 1750-1900 (3-6) *Mr. Silverman*

509. Studies in Twentieth Century Europe (3-6) *Mr. Forster*

512. Studies in Pennsylvania History (3-6) *Mr. Klein*

520. Colonial and Revolutionary America (3-6) *Mr. Frantz*

533. The United States, 1783-1860 (3-6) *Mr. Klein*

534. The United States, 1860-1877 (3-6) *Mr. Hassler*

535. The United States, 1877-1919 (3-6) *Mr. Murray*

536. The United States Since 1919 (3-6) *Mr. Murray*

538. Diplomatic History of the United States (3-6) *Mr. Maddox*

539. Economic History of the United States (3-6) *Messrs. McNall and Eggert*

540. Studies in British History (3-6) *Mr. Linker*

544. Seminar in Eastern European History (3-6)

545. Studies in Russian and Soviet History (3-6) *Mr. Enteen*

550. Problems in History (3-6)

552. Cultural History of the United States (3-6) *Mr. Brown*

562. Seminar in Latin-American History (3-6) *Mr. Ameringer*

563. Studies in the History of the Caribbean Area (3) Prerequisites: Hist. 22, 23. *Mr. Ameringer*

568. Studies in Greek History (3-6) *Mr. Borza*

569. Studies in Roman History (3-6) *Mr. Borza*

571. Studies in Asian History (3-9) *Mrs. Sun*

581. Studies in Middle Eastern History (3-6) *Mr. Goldschmidt*

598. Readings in History (1-6)

HOME ECONOMICS EDUCATION (HE ED)

Marjorie East, *Head of the Department*
212 Education Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors East and Hatcher.
Graduate Faculty, Associate Members: Associate Professors Ray and Shear.

Research and graduate courses may be chosen to give emphasis to special areas of interest in home economics education, such as curriculum development; evaluation; teaching at the elementary, secondary, adult, or higher education levels; supervision; administration in colleges; or research.

Students who have majored as undergraduates in some aspect of home economics and who have achieved a grade point average of at least 2.50 in their junior and senior years will be acceptable as candidates for the master's degrees. Students wishing to be admitted to the doctoral programs must have completed a master's degree, must present a score on the Miller Analogies Test, and will be admitted subject to limitations of departmental facilities. Exceptions will be made for students with special backgrounds, abilities, and interests.

HOME ECONOMICS EDUCATION (HE ED)

400v. Special Problems in Home Economics Education (1-3)
406v. Audio-Visual Methods for Home Economics (1-4)
410v. Supervision of Student Teachers (1-3)
427v. Teaching Home Economics (3)
443v. Adult Education in Home Economics (3)
463v. Senior Seminar (2)
466v. Student Teaching (9)
477v. Curriculum Development for Home Economics in Secondary Schools (3)
478v. Appraising Student Progress in Home Economics (3)
479v. Readings in Home Economics Education (1-4)
480v. Problems in Teaching Home Economics (3-6)
481v. Employment Preparation Programs in Vocational Home Economics (3)

502, 502v. Home Economics Instruction at the College Level (3) Teaching techniques suitable for college instruction in home economics; for prospective home economics college teachers.

503, 503v. Home Economics Teacher Education (3) Organization of college programs of teacher education; use of resources; records; field services; recruitment and selection of personnel. Prerequisite: two years' experience in teaching home economics.

504, 504v. Educational Issues and Home Economics (3) Contemporary issues in education and their relationship to the teaching of home economics. Prerequisite: teaching experience.

510, 510v. Educational Leadership in Home Economics (2-6) Principles of educational leadership for home economics preparing for administration; supervision of city and state programs; supervision of student teachers. Prerequisites: graduation from a four-year teacher education major and two years' teaching experience in home economics.

511, 511v. Internship in Home Economics Supervision and Administration (2-8) Opportunity to understudy an educational leader in student teacher supervision, state supervision, department or college administration, or regional consultation. Prerequisite: H.E.Ed. 510.

518, 518v. Evaluation of Home Economics Programs (3) Methods of evaluating progress toward goals in home economics education and use of findings in program planning and revision.

521, 521v. Home Economics Education Seminar (2-3) Selected topics and recent developments in home economics education. Conferences and guidance relative to individual research problems.

HOME ECONOMICS EDUCATION

530, 530v. Problems in Home Economics Education (1-6 per term) Individual investigation of problems related to the teaching, supervision, or administration of home economics education.

HORTICULTURE (HORT)

Darrell E. Walker, *Head of the Department*
101 Tyson Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty, Senior Members: Professors Grun, Hitz, Larson, Meahl, Odland, Ritter, Smith, Tukey, and Walker; Associate Professors Bergman, Creech, McArdle, and Stinson.

Graduate Faculty, Associate Members: Professor Mastalerz, Associate Professors Haramaki and Pfahl, Assistant Professors Craig and White.

Students may specialize in propagation, several phases of production, fruit and vegetable processing, plant genetics and breeding, plant nutrition, and various environmental and post-harvest physiological studies of horticultural crop species.

Students wishing additional credits in floriculture, olericulture, ornamental horticulture, plant breeding and genetics, plant nutrition, or pomology should register for Hort. 501.

Prerequisites for admission vary according to the area of specialization; but basic courses in physical sciences, mathematics, and biological sciences are required. Students who lack prerequisite courses may be admitted but are required to fulfill deficiencies without degree credit.

Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

HORTICULTURE (HORT)

401.	Plant Propagation (3)	*Mr. Haramaki*
402.	Plant Nutrition (3)	*Mr. Bergman*
403.	Horticultural Plants and Their Environment (3)	*Mr. Mastalerz*
404.	Advanced Horticultural Crop Science (3-12)	*Mr. Walker*
405.	Senior Seminar in Horticulture (1-2)	
407.	Plant Breeding (3)	*Mr. Creech*
412.	Post-Harvest Physiology (3)	*Mr. Ritter*
444.	Advanced Plant Breeding (3-6)	*Mr. Craig*
447.	Problems in Horticulture (1-9)	
451.	Flower Store Management (4)	*Mr. Pfahl*

500. Ecology of Fruit Plants (3) Factors limiting the distribution and intensity of culture of fruit species and varieties and effect of environmental factors on cultural practices. Spring term, even years. *Mr. Tukey*

501. Experimental Problems in Horticultural Science (1-12) Investigation of problems in floriculture, olericulture, ornamental horticulture, plant breeding, nutrition, or pomology. *Mr. Walker*

506. Nutrition of Horticultural Crops (2-4) Principles, applications, and interpretations of diagnostic methods for determining fertilizer requirements of horticultural crops. *Mr. Smith*

512. Principles of Fruit and Vegetable Storage (2-4) Principles involved in the maturation, storage, and senescence of fruits and vegetables, and their application. Winter term, odd years. *Mr. Ritter*

514. Propagation and Improvement of Horticulture Plants (1-6) Biological factors affecting sexual and asexual propagation of plants; techniques in plant improvement; maintenance of propagation material. *Mr. Meahl*

517. Horticultural Seminar (1 per term) Review of current research publications in horticulture. Each student presents one or more reviews of assigned topics.

520. Genetics and Breeding Seminar (1 per term) Review of research and literature in genetics and breeding of horticultural crops.

524. Experimental Procedures in Horticultural Research (3) *Mr. Craig*

525. Horticultural Research Techniques (3) Practice in and comparison of methods and apparatus used in horticultural research. Winter term, even years. *Mr. Tukey*

528. Problems in Fruit and Vegetable Processing (2-12) *Mr. McArdle*

INDUSTRIAL ARTS EDUCATION (I ART)

Gerald R. Bosch
In Charge of Graduate Programs in Industrial Arts Education
148 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Member: Associate Professor Pendered.
Graduate Faculty, Associate Member: Associate Professor Koble.

Emphasis may be placed on research, curriculum development, or teacher education. Graduation from an approved major in industrial arts and at least 18 credits in education and related psychology are required for admission. Students who present a 2.70 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

Graduate Record Examination scores on both aptitude and education sections are required of all candidates.

INDUSTRIAL ARTS (I ART)

400. Shop Management and Layout (3)
407. Curriculum Materials and Methods in Industrial Arts (4)
470. Problems in Senior High School Industrial Arts (3)

574. History and Philosophy of Industrial Arts (2-3) Historical developments and concurrent educational philosophies of industrial arts in American education. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

575. Problems in Industrial Arts Education (2-3) Subject matter, projects, methods of manual and informational teaching, aids and devices, selection of text and reference materials, personnel organization, shop management, problem pupils. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

576. Supervision and Administration of Industrial Arts Education (2-3) How to organize, supervise, and administer functioning programs of industrial arts; duties of a supervisor and director of industrial arts. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

577. Testing in Industrial Arts (2-3) Construction of informal manipulative and written tests; use of standardized mechanical aptitude and achievement tests; construction and use of rating scales; scoring and gradings; interpretation of test results. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

578. Research in Industrial Arts (2-3) Research techniques in industrial arts education. Prerequisite: 6 credits in professional courses in industrial arts.

580. Seminar in Industrial Arts (2-9) Directed intensive study, investigation, or research in selected phases of the program; reports and constructive criticism. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

INDUSTRIAL ENGINEERING (I E)

Benjamin W. Niebel, *Head of the Department*
207 Hammond Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty, Senior Members: Professors Lancaster, Niebel, and Schmidt; Associate Professors Draper and Ham.

Graduate Faculty, Associate Members: Professors Thuering and Zindler; Associate Professors Addison, Freark, Guild, Raphael, and Rosenshine; Assistant Professor Ermer.

Graduate study and research are conducted in management science, production engineering, process design, systems engineering, and human engineering.

Graduates in industrial engineering, other engineering curriculums and mathematics who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

INDUSTRIAL ENGINEERING (I E)

400. Engineering for Production (3)
402. Engineering Economy (3)
403. Engineering Economy and Statistics (3)
404. Management Science (3)
405. Quantitative Methods in Industrial Engineering III (3)
406. Design of Production and Distribution Systems (3)
422a,b,c,d,e,f. Industrial Engineering Problems (2-12)
423. Quality Control (3)

424. Job Evaluation (3)
425. Introduction to Operations Research (3)
426. Industrial Automation (3)
427. Solidification of Castings (3)
428. Foundry Engineering (3)
430. Industrial Leadership (3)
432. Industrial Engineering Lectures (1-3)
438. Metal Cutting Principles and Practice (3)

501. Manufacturing Methods (2-8) Special projects including investigation; experimentation, design, and research of one or more special types of manufacture.

502. Management Methods (3-6) Scientific management, including management controls and mathematical programming; research on special problems.

503. Industrial Relations (1-6) Study of human problems related to labor unions, hierarchy, specialization; analysis of organizational structure, policies, decision criteria, and communication systems.

504. Advanced Quantitative Methods in Industrial Engineering (3) Study of statistical and analytical decision models important in industrial engineering with emphasis on inference and testing of hypotheses. Prerequisites: Math. 62 and 3 credits in statistics.

506. Advanced Work Design and Measurement (3-9) Methods of research in motion and time study; critical analysis of current literature.

507. Analysis of Decision Processes (3-6) An introductory study of decision theory and its applications. Models and analyses of decisions under assumed certainty, risk, and uncertainty. Prerequisites: I.E. 323, 402.

508. Methods of Operations Research (3) Analytical approach to management decision-making including decision theory, game theory, constrained extremum theory; minimum cost transportation and network models. Prerequisites: Math. 100 and 3 credits in statistics.

509. Methods of Operations Research (3) Theory and application in decision-making including sequencing, line balancing, inventory, replacement, waiting line models, and Monte Carlo simulation. Prerequisites: Math. 100 and 3 credits in statistics.

510. Methods of Operations Research (3) Theory and application of mathematical programming including linear and dynamic programming, and an introduction to nonlinear, integer, and stochastic programming. Prerequisite: Math. 100.

511. Experimental Design in Engineering (3) Statistical design and analysis of experiments in engineering; experimental models and experimental designs using the analysis of variance. Prerequisites: Math. 63 and 3 credits in statistics.

512. Graph Theory and Networks in Management Science (3) Prerequisite: I.E. 405.

513. Real Time Data Processing for Engineering Systems (3) Random access computers and communication components for real time systems; engineering systems simulation on digital computers. Prerequisite: Cmp.Sc. 102 or 410.

515. Complex Linear Flow Models (3) Application of complex linear flow models in engineering and management science, including static and dynamic system simulations. Prerequisite: I.E. 512.

516. Applied Stochastic Processes I (3) Prerequisites: I.E. 323, Stat. 418.

517. Applied Stochastic Processes II (3) Prerequisite: I.E. 516.

518. Plastic Deformation Processes (3) Study of the principles, theories, technology, design, and application of plastic deformation processes to shape metals. Prerequisite: undergraduate engineering degree.

528. Metal Cutting Theory (3) Study of the theory of metal cutting, contemporary and future problems of metal removal processes; critical analysis of current literature. Prerequisite: I.E. 438.

538. Experimental Investigations in Materials Processing (3) Experimental investigation on selected subjects in processing involving instrumentation, methods, and analysis. Prerequisite: I.E. 528.

JOURNALISM (JOURN)

Robert M. Pockrass
In Charge of Graduate Programs in Journalism
220 Carnegie Building

Degree Conferred: M.A.

Graduate Faculty, Senior Members: Professors Barnes, Brown, and Harrison.
Graduate Faculty, Associate Members: Professor Goodwin; Associate Professors Froke, Norris, and Pockrass; Assistant Professor Jones.

The program is designed to be as responsive as possible to the needs of students who bring to it different undergraduate and/or professional backgrounds. It can give to those students who have had professional training or experience an understanding of the theory and practice of mass communications as well as a critical insight into the structure and functions of mass communications industries and an introduction to research on communications problems. At the same time, it offers students with substantial backgrounds in the social sciences or humanities the opportunity to prepare themselves professionally to enter the media of mass communications or allied fields.

Although an M.A. candidate is normally expected to write a thesis and complete a minor of 12 credits, one of those requirements may be waived or substituted when such action is compatible with the academic and career goals of the individual student.

Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

JOURNALISM (JOURN)

401. Critics and Ethics of the Mass Media (3) *Mr. Harrison*
405. International Mass Communications (3) *Miss Jones*
406. Evaluation and Uses of Mass Communications Research (3) *Mr. Colldeweih*
419. (Spch. 419) Comparative Broadcasting Systems (3)
421. Editorial Interpretation (3) *Messrs. Brown and Harrison*
422. Cultural Aspects of the Mass Media (3) *Mr. Pockrass*
424. Public Affairs Reporting (3)
430. Journalism in the Schools (3-6)
436. (Soc. 436) Sociology of Opinion Formation (3)

442. Special Topics in Advertising (3)
443. Advertising Campaigns (3) *Mr. Rotzoll*
444. Advertising in Contemporary Society (3) *Mr. Norris*
466. Public Relations Problems (3)
468. Law of Mass Communications (3) *Mr. Smith*
470. Reporting of Contemporary Issues (3)
481. News Evaluation and Presentation (3)
492. Public Affairs Broadcasting (3) *Mr. Farson*
499. Independent Study in Mass Communication (2-6) *Mr. Goodwin*

504. Seminar in the History of Mass Communication (3) *Mr. Harrison*

505. International Communication Problems (3) Legal and communications problems of the international flow of news and opinion; international press codes. *Miss Jones*

506. Introduction to Mass Communications Research (3) The scientific method; survey of basic concepts of theoretical and empirical research; variety of methodology; criteria for adequate research.

508. The Literature of Journalism (3) *Mr. Brown*

510. Mass Communications Research Methods I (3) Design of research on processes and effects of mass communications; data analysis and hypothesis testing. Prerequisite: Journ. 506 or Stat. 400.

511. Mass Communications Research Methods II (3) Problems of bibliographical research; evaluation of sources and materials in mass communications history, biography, structure, ethics, and other areas. Prerequisite: Journ. 506.

513. Constitutional Problems of the News Media (3) Problems involving conflict between guarantees of press freedom in the First and Fourteenth Amendments and rights and privileges of others. *Mr. Harrison*

521. News Media and Public Opinion (3) Problems in the function, techniques, and responsibilities of press, radio, and television in forming and interpreting opinion. Prerequisite: Pl.Sc. 427. *Mr. Pockrass*

524. Government and Mass Communications (3) Problems of freedom of information; governmental efforts to control mass communication agencies; government news coverage; public information agencies. *Mr. Smith*

540. Seminar in Advertising Problems (3) *Mr. Norris*

545. Advertising and Consumer Behavior (3) Examination of theories of human behavior as they apply to the study of advertising's effects on consumer behavior.

585. Comparative Theories of Press Systems (3) Institutional structure and normative functions of press systems in modern societies, as shaped by prevailing world view and social organization. *Mr. Norris*

LABORATORY ANIMAL MEDICINE (L A M)

C. Max Lang, *Chairman, Department of Comparative Medicine*
The Milton S. Hershey Medical Center

Degree Conferred: M.S.

LABORATORY ANIMAL MEDICINE

Graduate Faculty, Senior Member: Assistant Professor Lang.

The department offers a postdoctoral program for veterinarians leading to the Master of Science degree with a major in laboratory animal medicine. Laboratory animal medicine is a specialty of veterinary medicine that is concerned with the biology of laboratory animals and their comparative relationships to man. Postdoctoral training in this discipline provides a broad, basic foundation upon which the individual can build a career in teaching and research in laboratory animal medicine and/or in the professional direction of research animal facilities. The program has a strong research-oriented base with emphasis on comparative medicine and pathology.

The program requires two years for completion. Basically, the first year consists of formal course work, while the second year is devoted mainly to research and the development of clinical skills and techniques. A student must have earned a minimum of 12 credits in a major subject, 6 credits in a minor subject, and 6 credits of thesis research in order to receive the graduate degree. Approved minors have been established in anatomy, behavioral science, biological chemistry, microbiology, pathology, pharmacology, and physiology.

Students who present a 2.75 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests. This program is offered only at The Milton S. Hershey Medical Center. For course listings at the center see pages 259 to 265.

MAN-ENVIRONMENT RELATIONS (M E R)

RAYMOND G. STUDER, *Director of the Division*
S-126 Human Development Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors Tesi, Thompson, Vallance; Associate Professors Carson and Densmore.

Graduate Faculty, Associate Members: Professor Studer, Associate Professor Van Dommelen, Assistant Professors Berman and R. Smith.

Graduate instruction and research opportunities are available in the application of tools and knowledge in the basic sciences to the understanding and organization of various man-environment systems. This broad, interdisciplinary program deals with the effects of man-made environments, e.g., food, clothing, shelter, upon human biological, behavioral, and social outcomes. Included is the development of methodological and empirical resources required to realize and maintain environmental support systems for various human goals and settings. Students in this program may specialize in *Clothing and Textiles* and *Food Service and Housing.* These areas of specialization have been organized under a unifying structure to provide an interdisciplinary, integrative base (see courses 500-503). Specialization in Clothing and Textiles provides an approach to understanding the role and technical requirements of clothing and textiles for individuals, families, industries, and nations. Specialization in Food Service provides professional training for management positions in hospitals, educational systems, and other public and private settings. Specialization in Housing provides training for professionals involved in programming, planning, and managing the micro and macro aspects of large-scale housing systems in both the public and private sectors.

Depending upon the specialization selected, undergraduate preparation may be in one of the above or related areas, in the physical, behavioral or social sciences, or in environmental and urban studies. Deficiencies, assigned on an individual basis, may

be removed concurrent with graduate studies. Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

CLOTHING AND TEXTILES (CL TX)

400. Special Problems in Clothing and Textiles (1-6)
408. Intermediate Textiles: 408L (2), 408P, (1-3)
410. Clothing for the Family (3)
415. Functional Clothing Design (3-12)
416. Western Costume Development from the Renaissance to the Present (3)

HOUSING AND INTERIORS (H I)

401. Advanced Interiors I (3)
402. Advanced Interiors II (3-9)
470. Housing Problems and Policies (3)

FOOD SERVICE AND HOUSING ADMINISTRATION (FS HA)

402. Food Service and Housing Layout and Design (3)
410. Advanced Quantity Food Production (3)
425. Food and Labor Management and Control (3)
461. Personnel Functions in Food Service and Housing Administration (3)
470. Problems in Food Service and Housing Administration (3)

MAN-ENVIRONMENT RELATIONS (M E R)

500. Nonthesis Research (1-6)

501. Problems in Man-Environment Relations (1-9) Individual directed study, investigation and practice in selected aspects of man-environment relations.

502. Seminar in Man-Environment Relations (1-9)

503. Research Methods and Evaluation in Man-Environment Relations (1-9)

520. Recent Developments in Textiles (3) Developments in fibers, yarns, fabrics, finishes; effects on use and care; discussions and reports based on current literature.

521. Clothing Behavior (3) Analysis and interpretation of clothing behavior through application of theories selected from the behavioral sciences.

522. Clothing Production, Distribution and Consumption Systems (3) Problems connected with manufacture and consumption of clothing; interrelation of textile and clothing trades with other industries.

523. Societal Determinants in Clothing and Textile Development (1-6)

525. Textile Technology (6)

540. The Proximate Housing Environment (3) Evaluation of useful objects in respect to their form, function, and time; selection for exhibition.

541. Aesthetic Aspects of Housing (3) Approach based upon human needs with consideration of materials in the light of their use in home living.

MATHEMATICS (MATH)

RAYMOND G. D. AYOUB, *Head of the Department*
228 McAllister Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty, Senior Members: Professors Anderson, Axt, C. Ayoub, R. Ayoub, Chowla, Fine, Hammer, Hunter, Kanwal, H. Krall, and Ribeiro; Associate Professors Andrews, Hahn, A. Krall, Petrich, and Rung.

Graduate Faculty, Associate Members: Associate Professors Mack and M. McCammon; Assistant Professors Bollinger, Bond, Deutsch, Grilliot, James, Maserick, McLaughlin, Morris, Pearson, and Stevens.

Graduate courses in all the principal branches of mathematics are offered each year. The department is prepared to direct research in a variety of fields, including various branches of analysis, algebra, topology, number theory, numerical analysis, applied analysis, and mathematical logic and foundations. A digital computer is available on the campus for students interested in numerical methods.

To be admitted to the M.A. or Ph.D. program without undergraduate deficiency, an applicant should have completed at least three courses in mathematics at the advanced undergraduate level (400 series) or their equivalents. The undergraduate student is urged to take at least 6 credits in foundations of analysis (Math. 420-421) *and* 6 in modern algebra (Math. 480-481) or their equivalents. These courses are essential to prepare for the graduate program and, if they are taken after admission, only 6 credits at most may be counted toward an advanced degree.

Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

Entering graduate students in mathematics for whom English is not the first language are required to have a score of at least 450 on the TOEFL (Test of English as a Foreign Language) examination. Furthermore, the results of this examination must be received by the Department of Mathematics at least six months prior to the requested date of admission to the Graduate School.

For the M.A. degree the department offers two options:

(1) The *thesis* option requires 12 credits of approved 500-series courses in mathematics, 6-9 credits of thesis, sufficient credits in approved 400- or 500-series courses to make a total of 30 credits, and a final (oral) examination based on the thesis and general course material.

(2) The *non-thesis* option requires 18 credits of 500-series courses in mathematics with grades of A or B, sufficient credits in approved 400- or 500-series courses to make a total of 30 credits, and a term paper on an approved topic in mathematics. No final examination is given in this option.

All first-year students who are working toward the M.A. or Ph.D. degree are required to enroll in Math. 498 for two successive terms. All Ph.D. students, before they have accumulated 48 graduate credits earned at the University or elsewhere, *must* take qualifying examinations in three fields of mathematics and have a reading or introductory knowledge of two foreign languages, or comprehensive knowledge of one. Recommendations for advancement to Ph.D. candidacy are based on these examinations. The comprehensive examination is given after approximately 60 credits and only after the student has passed a reading examination in a second of the foregoing languages.

To be admitted to the M.Ed. program without undergraduate deficiency in mathematics, an applicant should have at least 27 credits in mathematics including at least 15 at the intermediate level beyond calculus. The M.Ed. program does not require

any 500-level courses, but the student is encouraged to select some at this level.

For the D.Ed. degree, a student must pass a reading examination in French, German, or Russian before he is allowed to take the comprehensive examination. In addition to the major thesis, the department requires participation in two terms of a research seminar, but no minor thesis is required.

Special courses have been instituted for the training of teachers. Among these are Math. 400, 401-402, 415, 416, and 470-471. These are acceptable for the satisfaction of credit requirements only for the M.Ed. and D.Ed. degrees.

MATHEMATICS (MATH)

400. Probability for Teachers (3)
401-402. Geometry for Teachers (3 each)
404. Theory of Numbers (3)
405. (A.M. 405) Fourier Series and Partial Differential Equations (3)
406. Topics in Theory of Numbers (3)
407. Foundations of Algebra and Geometry (3)
409-410. (Stat. 409-410) Introduction to Mathematical Statistics (3 each)
411. Finite Differences (3)
413-414. Mathematics of Science for Teachers (3 each)
415. Survey of Modern Mathematics for Teachers (3)
416. Mathematical Logic for Teachers (3)
417. (A.M. 417) Tensor Analysis (3)
418. (A.M. 418, Stat. 418) Discrete Probability Theory (3)
420-421. Introduction to Analysis (3 each)
425-426. Analysis for Teachers (3 each)
428. (Phil. 428) Logical Theory (3)
431. (A.M. 431) Ordinary Differential Equations (3)
435. Axiomatic Set Theory (3)
441. (A.M. 441) Matrix Algebra (3)
452. (A.M. 452) Functions of a Complex Variable (3)
453. (Cmp.Sc. 453) Numerical Computations (3)
454. (Cmp.Sc. 454) Matrix Computations (3)
470-471. Algebra for Teachers (3 each)
472. Foundations of Geometry (3)
473. Elementary Point-Set Topology (3)
480-481. Introduction to Modern Algebra (3 each)
491. Topics in Applied Mathematics (3-9)
498. Mathematics Seminar (1-6)

501-502. Theory of Functions of a Real Variable (3 each) Sets, metric spaces, measure and integration, Lp spaces and other function spaces, differentiation. Prerequisite: Math. 421.

503. Fourier Analysis (3) Fourier series and integrals, convergence and summability, theorems on Fourier coefficients, uniqueness properties. Prerequisite or concurrent: Math. 502.

505. Integral Equations (3) Fredholm and Volterra equations, and applications. Prerequisite: Math. 421.

507. Calculus of Variations (3) Prerequisite: Math. 421.

508-509. Complex Analysis (3 each) Analytic and meromorphic functions; Riemann's mapping theorem. Prerequisite: Math. 421.

511. Linear Algebra (3) Vector spaces and linear transformations, canonical representations, elementary divisors and invariant factors. Prerequisite: Math. 481 or 537.

515. Partial Differential Equations of Mathematical Physics (3) Methods of solution of selected elliptic, parabolic, and hyperbolic partial differential equations, with reference to physical application. Prerequisite: Math. 421.

517-518. (Stat. 517-518) Probability Theory (3 each) Measure theoretic foundation of probability, distribution functions and laws, types of convergence, central limit problem, conditional probability, special topics. Prerequisites: Math. 452, 501.

523. Metric Differential Geometry (3) The usual classical treatment of the subject. Prerequisite: Math. 63.

524. Advanced Complex Analysis (3) Topics include boundary behavior of analytic functions, bounded analytic functions, conformal mapping, theory of Riemann surfaces. Prerequisite: Math. 509.

525. Theory of Functions of Several Complex Variables (3-6) Topics include fundamental properties of holomorphic functions, complex analytic manifolds, integral representations, Cousin problems. Prerequisite: Math. 509.

529-530-531. Topology (2 each) Topological, product, compact, metric, and connected spaces; continuous functions; separation axioms, countability conditions, combinatory topology.

532. Theory of Sets (3) Formal development of set theory on a logical basis and related methodological problems; applications to the foundations of mathematics. Prerequisite: Math. 428.

533. Analytic Theory of Numbers (2-6) Topics selected from Dirichlet's Theorem on primes in A. P., Riemann Zeta-function, distribution of primes, Waring's problem, Goldbach's problem, partitions. Prerequisites: Math. 404 or 480; Math. 508.

534. Elementary and Algebraic Number Theory (2-6) The arithmetic and ideal theory of higher algebraic number fields will be emphasized, together with the necessary rational number theory. Prerequisite: Math. 480.

535-536-537. Algebra (2 each) Basic theory of semigroups and groups, rings and modules, fields, lattices. Prerequisites: Math. 480 (535) and 481 (536).

538. Commutative Algebra (3) Topics selected from noetherian rings and modules, primary decompositions, Dedekind domains and ideal theory, other special types of commutative rings or fields. Prerequisite: Math. 536.

539. Rings (3) Selected topics from the theory of rings. Prerequisite: Math. 536.

540. Valuation Theory (3) Selected topics from the theory of valuations on a field including completeness, extensions, ramification, local and global fields, adeles and ideles.

542-543. (Stat. 542-543) Statistical Distribution Theory (3 each) Random variables and expectations; discrete, continuous, univariate, multivariate, exact, and asympotic distribution theory. Prerequisites: Math. 421 and 441 or 481.

544-545-546. General Topology (2 each) Topics selected including uniform spaces, function spaces, and proximity spaces. Prerequisite: Math. 531.

547-548-549. Lie Theory (2 each) Topics selected from theory of topological semigroups, topological groups, lie groups, transformation groups. Prerequisite: Math. 531.

550-551. (Phil. 550-551) Foundations of Mathematical Logic (3 each) The

nature of logical basis of mathematics; critical examination and development of the basic parts of logical calculus. Prerequisite: Math. 480 or 428.

552. Numerical Analysis (3) Interpolation; remainder theory; approximation of functions; error analysis; orthogonal polynomials; approximation of linear functionals; functional analysis applied to numerical analysis. Prerequisites: Math. 420, 453.

553. Numerical Analysis (3) Eigenvalue and eigenvector determination; numerical solution of integral equations and ordinary differential equations with error and stability analysis. Prerequisites: Math. 420; Math. 454 or 481.

554. (Phil. 554) Logic and Metamathematics I (3) Completeness, Löwenheim-Skolem, Herbrand, and compactness theorems; first-order theories; categoricity, elimination of descriptions; decidability; algebraic and geometric applications. Prerequisite: Math. 428.

556. (Phil. 556) Recursion Theory (3) Recursive functions; normal form, enumeration and separation theorems; partial recursive functions; recursion theorems; special recursive functions; alternate formulations; related topics. Prerequisite: Math. 428.

557. (Phil. 557) Logic and Metamathematics II (3) Arithmetization; Gödel and Tarski incompleteness theorems; undecidability results; Gentzen-type systems and consistency results. Prerequisites: Math. 554, 556.

558-559. (Stat. 558-559) Theory of Stochastic Processes (3 each) Stationary, independent, and orthogonal processes; discrete and continuous Markov processes; martingales and semi-martingales applications. Prerequisite: Math. 518.

560-561. Theory of Differential Equations (3 each) Topics selected from existence and uniqueness of solutions of differential systems, Sturm-Liouville systems, eigenvalue problems, integral operator solution. Prerequisites: Math. 72 or 83 or 100, and 508.

562. Theory of Special Functions (3) Topics include asymptotic expansions; Riemann-Papperitz and Trusdell's F equations; orthogonal polynomials; generating, beta, zeta, hypergeometric, Bessel, Legendre, elliptic functions. Prerequisites: Math. 72 or 83 or 100 and either Math. 420 and Math. 452 or Math. 508.

563. Approximation Theory (3) Approximation in normed spaces; existence, uniqueness, characterization, computation of best approximations; error bounds; degree of approximation; approximation of linear functionals. Prerequisites: Math. 501, 453.

564. Numerical Solution of Partial Differential Equations (3) Numerical solution of initial and boundary-value problems; eigenvalues and eigenfunctions; errors, stability, and convergence. Prerequisite: Math. 552.

565. Functional Analysis (3) Theory of Banach and Hilbert spaces, including functionals and operators, and related topics. Prerequisite: Math. 502.

570. Special Topics in Geometry (3-12)

571. Special Topics in Analysis (3-12)

572. Special Topics in Algebra (3-12)

573. Special Topics in Applied Mathematics (3-12)

574. Special Topics in Foundations of Mathematics (3-12)

575-576. Mathematics Seminar (1-6 each) Selected topics from recent mathematical developments.

577. (Stat. 577) Special Topics in Probability (3-12) Special topics in probability which are not offered regularly but which are of special interest to faculty and students.

578. Special Topics in Topology (3-12)

579. Special Topics in Numerical Analysis (2-12)

*580. Special Topics in Number Theory (2-12)

581-582. Group Theory I, II (3 each) Selected topics from group theory including Abelian, solvable, nilpotent, and free groups, Sylow theorems, and group extensions and representations. Prerequisite: Math. 535.

583. Homological Algebra (3) Modules, diagrams, functors, homology of complexes, resolutions, cohomology of groups, tensor and torsion products. Prerequisite: Math. 536.

584-585-586. Algebraic Topology (2 each) Development of singular and Cech homology and cohomology theories; homotopy and cohomotopy theories. Prerequisite: Math. 531.

587-588-589. Point Set Topology (2 each) Topics selected from point set topology including upper semicontinuous and continuous decompositions, theory of continua, dimension theory. Prerequisite: Math. 531.

591. (Stat. 591) Seminar in Probability Theory (1-6) Lectures on current and recent research in various special topics in probability theory.

Note: *Courses in Applied Mathematics, Computer Science, and Statistics are listed separately.*

MECHANICAL ENGINEERING (M E)

Richard G. Cunningham, *Head of the Department*
207 Mechanical Engineering Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty, Senior Members: Professors Brickman, Cunningham, DiIlio, McLaughlin, Meyer, Olson, Reethof, and Shearer; Associate Professors Brighton, Faeth, Heinsohn, Lestz, and Schmidt.

Graduate Faculty, Associate Members: Associate Professors DeCarolis, Park, Parke, Wolgemuth, and Zimmerman; Assistant Professors Baker, Bowlus, Healey, and Wambold.

Graduate programs and research facilities are available in thermodynamics and combustion, heat transfer, fluid mechanics, dynamic system analysis, mechanical design, automatic controls, and fluid amplifiers. Air pollution control, automotive safety, designing for noise control and for reliability also provide many research and design opportunities.

The entering student must hold a bachelor's degree in engineering or physical science. Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the

* Credits to be arranged, 2-3 per term.

limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

MECHANICAL ENGINEERING (M E)

401. Mechanical Engineering (3-12)
402. Air Conditioning and Life Support Systems (3)
403. Rocket Propulsion (3)
405. Small Particle Technology (3)
409. Gas Turbines (3)
410. Power Plants (3)
411. Refrigeration (3)
412. Heat Transfer (3)
413. Internal Combustion Engines (3)
417. Theory of Engineering Instruments (3)
418. Principles of Turbomachinery (3)
421. (Aersp. 421) Intermediate Viscous Flow (3)
422. (Aersp. 422) Intermediate Inviscid Flow (3)
450. Design of Machine Tools (3)
451. Advanced Machine Design Problems (3)
452. Design Analysis (3)
453. Bearing Design and Lubrication (3)
455. Automatic Control Systems (3)
457. Advanced Mechanisms (3)
460. Reliability Concepts in Design (3)

500. Special Topics in Thermodynamics (2-6)

503. Thermodynamic Process Analysis (3) Development of equations governing separate processes in complete machines to give basic system parameters and characteristics; transient processes; irreversible effects.

504. Advanced Engineering Thermodynamics (3-6) Pure and applied thermodynamics including its application to advanced engineering problems; collateral reading and discussion of the classical works on the subject. Prerequisite: M.E. 42.

506. Selected Topics in Mechanical Engineering (1-12) Advanced courses adapted to the individual requirements of graduates in mechanical engineering.

512. Heat Transfer—Conduction (3) One- and two-dimensional conduction heat transfer for steady state and transient systems with varying boundary conditions.

513. Heat Transfer—Convection (3) Laminar and turbulent flow heat transfer in natural and forced convection systems.

514. Heat Transfer—Radiation (3) Thermal radiation fundamentals; specular and diffuse systems; differential and integral methods; numerical techniques; industrial applications.

517. Special Topics in Transport Phenomena (2-6)

519. Compressible Fluid Flow (2-4) Two-dimensional subsonic flow; similarity rules; theory of characteristics; supersonic and hypersonic flows; nonsteady flow; oblique shock waves.

521. Electromagnetic and Thermodynamic Flow Systems (3) Thermodynamic equations for flow of reacting and nonreacting fluids in electromagnetic fields; applications to engineering problems.

522. Boundary Layer and Separated Flows (3) Behavior of viscous fluids, with emphasis on boundary layer and separation effects in internal flow.

540. Simulation of Mechanical Engineering Phenomena (3) Analog and numerical methods for simulation of problems in thermodynamics, heat transfer, fluid mechanics, diffusion, and machine dynamics.

550. Analysis of Design Problems (3) Case problems in machine design requiring integrated application of engineering knowledge.

551. Special Topics in Design and Controls (2-6)

552. Advanced Dynamics of Machines (3-6) Linear and torsional vibrations in and balancing of rotating and reciprocating machinery; exact analysis of stresses produced by these and other dynamic forces in machine parts. Prerequisites: E.Mch. 12, M.E. 54.

553. Friction and Lubrication (3) Sliding and rolling surface phenomena; hydrostatic, hydrodynamic, and magnetohydrodynamic lubrication theory; design and control of gas and fluid lubricated bearings.

555. Automatic Control Systems (3) Advanced problems and techniques in the design of automatic control systems with emphasis on stability, controller design, and optimum performance. Prerequisite: M.E. 455.

556. Advances in Control Systems Analyses (3) Control system theory and applications of newly developed theory to engineering systems; nonlinear systems, distributed systems, state-space methods. Prerequisite: M.E. 555.

557. Mechanism Synthesis (3) Geometrical and algebraic methods for synthesizing planar and spatial mechanisms, dynamics of spatial mechanism.

558. Fluid Control Systems (3) Systems elements, simplified models, analysis of interacting elements, instrumentation; computer-aided case study, and experimental investigations. Prerequisite: M.E. 555.

560. Probabilistic Methods in Machine Design (3) Reliability determination of machines for various types of interfering stress and strength probability functions. Probabilistic life consumed modeling. Prerequisites: Math. 409 or M.E. 460 or I.E. 323, M.E. 42, 54.

580. Investigation Projects (2-6) Special experimental studies or investigations in mechanical engineering, adapted to individual requirements.

MEDICAL TECHNOLOGY (MED T)

Robert W. Stone
In Charge of Graduate Program in Medical Technology
206 Patterson Building

Degree Conferred: M.S.

Graduate Faculty, Senior Members: Professors Anthony, Grun, Ludwig, O'Mara, Pazur, Stone, and Zimmerman; Associate Professors Hayes, Houlihan, and Wickersham; Assistant Professor McCarl.
Graduate Faculty, Associate Member: Associate Professor Pootjes.

This is an interdisciplinary program designed for the registered medical technolo-

gist to obtain further academic training and some research experience. Students should expect to spend approximately one year (3 terms) at the University Park Campus taking course work and a second year at a cooperating hospital school doing a research problem for the master's thesis. Opportunities are available for course work and research in biology, biochemistry, clinical chemistry, immunology, microbiology, physiology, and virology. Research at the hospital school is under the joint supervision of a clinical scientist at the hospital and a University staff member.

For admission a student must have a bachelor's degree with an academic average of 2.50 or better for the last two years of undergraduate work. Also the candidate should be a registered Medical Technologist (ASCP) and have had at least one year of laboratory experience following registration. Exceptions to these requirements may be made for students with special backgrounds, abilities, and interests.

For courses offered see majors in Biochemistry, Biology, Biophysics, Chemistry, and Microbiology.

METALLURGY (METAL)

William R. Bitler
In Charge of Graduate Programs in Metallurgy
221 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Lindsay, Muan, and Read; Associate Professors Bitler, Healy, Hoke, Inman, Ryba, and Simkovich.

This program is one of the options in which a graduate student in the Department of Materials Science can receive an advanced degree.

A student may specialize, through both course work and research, in the science and engineering aspects of chemical, physical, or mechanical metallurgy.

Suitable preparation for graduate study in this program may be found in one of the materials sciences such as ceramic science, fuel science, metallurgy, or solid state science; in engineering fields such as chemical or mechanical engineering; in basic physical sciences such as chemistry or physics; or in earth sciences such as geochemistry and mineralogy. Students having at least a 2.50 junior-senior average and appropriate supporting information will normally be accepted subject to limitations of the departmental facilities. Exceptions to these requirements may be made for students with special backgrounds, abilities, and interests.

METALLURGY (METAL)

401. Metallurgical Processes and Kinetics (3)
402. Electrometallurgy, Hydrometallurgy, and Corrosion (3)
404. Pyrometallurgy (3)
405-406. Metallography (3 each)
407. Metallurgical Engineering I (3)
408. Metallurgical Engineering II (3)
410. Metallurgical Investigations II (3)
412. Solid-State Metallurgy (3)
459. Metallurgical Applications for Engineers (3)

501. Metallurgical Problems (1-6 per term) Independent study of special problems in metallurgy.

502. Seminar in Metallurgy (1-6) Conferences, reading, reports, and special lectures.

508. Kinetics of Phase Transformations (3) Application of statistical mechanics and absolute rate theory to kinetics of phase transformations, including diffusion, nucleation, and growth rates. *Mr. Bitler*

509. Introductory Theoretical Physical Metallurgy (3) Quantum mechanics and its application to solid-state theory; introduction of Schroedinger's equation, its solutions, free-electron model, band model. *Mr. Bitler*

510. Magnetic and Transport Properties of Materials (3) Treatment of the magnetic and transport properties of solids by quantum mechanics with applications to practical alloy development. Prerequisite: Metal. 509. *Mr. Bitler*

511. Advanced Physical Metallurgy (3) Physical metallurgy of an advanced nature; consideration of solid state bonding, crystal structure, alloy constitution. Prerequisite: Metal. 509. *Mr. Ryba*

513. Advanced Chemical Metallurgy I (3) Application of thermodynamics and kinetics to the heterogeneous metallurgical processes of oxidation, reduction, smelting, and refining. Prerequisites: Chem. 452, Metal. 301, 402, 404. *Mr. Healy*

514. Dislocation Theory (3) Self and interaction energies of dislocations and other defect structures; dislocation motions and their relation to mechanical properties. *Mr. Bitler*

515. Corrosion of Metals (3) Phenomena and theories of metallic corrosion; principles of alloy selection for engineering and structural uses in corrosive environments. *Mr. Read*

516. Flow and Fracture of Solids (3) Phenomenological and theoretical treatment of flow and fracture in solids. Prerequisites: Metal. 511, 514. *Mr. Hoke*

518. Heterogeneous Equilibria at High Temperatures (2-3) Treatment of high-temperature equilibria in metal and oxide systems involving crystalline, liquid, and gas phases. Prerequisite: Metal. 513. *Mr. Muan*

519. Advanced Chemical Metallurgy II (3) Application of thermodynamics and kinetics to precipitation of nonmetallic and metallic phases from liquid and solid metals at elevated temperatures. Prerequisite: Metal. 513. *Mr. Healy*

520. Foundry Metallurgy (3) Physical-chemical considerations of the liquid state, solidification, and the solid state as applied to casting of metals and alloys. Prerequisites: Metal. 511, 513. *Mr. Lindsay*

522. Solid-Phase Reactions in Metals (3) Mechanisms and rate determining factors in solid-phase reactions in metals; diffusion processes, nucleation theory, precipitations from solid solution, eutectoid decomposition and order-disorder phenomena. Prerequisites: Metal. 508, 511. *Mr. Bitler*

525. Metal Finishing (3) Metallic coatings and their metallurgical properties; theories and problems of application, utilization, and evaluation. Prerequisite: Metal. 515. *Mr. Read*

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in metallurgical studies are listed under Materials Science.*

METEOROLOGY (METEO)

ALFRED K. BLACKADAR, *Head of the Department*
503 Deike Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Blackadar, Hosler, Neuberger, and Panofsky; Associate Professor Dutton.

Graduate Faculty, Associate Members: Associate Professor Lavoie, Assistant Professor Kreitzberg.

Candidates may specialize in the study of problems in either theoretical or applied meteorology including such areas as cloud physics, various phases of dynamic meteorology including turbulence and atmospheric circulation, atmospheric optics and electricity, macro- and micro-climatology, synoptic meteorology, or meteorological instrumentation. The department also encourages interdisciplinary studies in such fields as agricultural meteorology, biometeorology, water resources, air pollution, and fluid mechanics.

Requirements for admission include mathematics through differential equations and one year of college physics. Undergraduate study of meteorology is not required for admission. Special programs are available to encourage the graduate study of meteorology by all students with strong backgrounds in mathematics, physics, or engineering. Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

METEOROLOGY (METEO)

400. METEOROLOGY FOR TEACHERS (3)
401. PHYSICAL CLIMATOLOGY FOR TEACHERS (3)
402. BIOMETEOROLOGY FOR TEACHERS (2)
403. SCIENCE PROJECTS IN METEOROLOGY (1)
404. PHYSICS OF WEATHER FORECASTING (3)
411. INTRODUCTION TO SYNOPTIC METEOROLOGY (3)
418. INTRODUCTORY PHYSICS OF THE UPPER ATMOSPHERE (3)
420. TROPICAL METEOROLOGY (3)
430. INTRODUCTION TO SYNOPTIC METEOROLOGY LABORATORY (2)
431. SYNOPTIC METEOROLGY LABORATORY I (2)
432. SYNOPTIC METEOROLOGY LABORATORY II (2-10)
433. ADVANCED SYNOPTIC ANALYTICAL TECHNIQUES (3)
443. PHYSICAL METEOROLOGY (3)
445. HYDROLOGY FOR METEOROLOGISTS (3)
450. APPLICATIONS OF STATISTICS TO METEOROLOGY (3)
451. INTRODUCTION TO DYNAMIC METEOROLOGY (3)
452. HYDRODYNAMICS OF THE ATMOSPHERE (3)
453. ATMOSPHERIC THERMODYNAMICS (3)
461. THEORY OF METEOROLOGICAL INSTRUMENTS (3)
472. PHYSICAL AND DYNAMIC CLIMATOLOGY (3)
473. INTRODUCTION TO MICROMETEOROLOGY (3)
492. METEOROLOGICAL SEMINAR (1-2)

500. METEOROLOGICAL SEMINAR (1-3) Discussion of meteorological reports and papers; scientific outlook. Prerequisites: Meteo. 411, 451.

502. Selected Topics of Advanced Meteorology (1-3 per term) Current problems in meteorology. Prerequisite: a minimum of 15 credits in meteorology.

503. Atmospheric Turbulence (3) Atmospheric diffusion, heat conduction, friction, and evaporation; statistical properties of turbulence.

505. Bioclimatology (2) Climatic phenomena in their relation to life. Prerequisite: Meteo. 472.

506. Advanced Meteorological Analysis (2-6) Physical analysis of atmospheric phenomena; synoptic analysis of weather phenomena for advanced students.

507. Dynamic Oceanography (2) Physical properties of sea water; heat balance of the oceans; theory and observations of ocean currents, waves, and tides.

508. Physics of the Upper Atmosphere (2) Temperature distribution, composition, and electrical characteristics of the upper atmosphere; theories of aurora and light of the night sky.

509. Theoretical Climatology (2) Theory of latitudinal, annual, and diurnal temperature changes; theories of climatic changes, microclimate.

510. Cloud Physics (2) Current theories on phase changes in clouds and mechanisms responsible for precipitation; techniques of cloud modification and control.

550. Atmospheric Motions (3) Fundamental properties and conservation requirements of the hydrodynamic equations; elements of advanced dynamic meteorology and applications to atmospheric dynamics. Prerequisite or concurrent: A.M. 451.

551. Atmospheric Wave Motion (2) From classical and physical hydrodynamics to the numerical prediction of wave motion in a baroclinic atmosphere. Prerequisite: Meteo. 452.

552. Advanced Atmospheric Dynamics (2) Numerical prediction models, general circulation, thermal and gravitational tides in a spherical shell, and empirical orthogonal functions of statistical forecasting. Prerequisite: Meteo. 551.

553. Energetics of Atmospheric Motion (2) Theoretical investigation of the conversions of energy in the atmosphere; maintenance of the general circulation. Prerequisite: Meteo. 452.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in meteorological studies are listed under Materials Science.*

MICROBIOLOGY (MICRB)

Robert W. Stone, *Head of the Department*
206 Patterson Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Casida, Dunne, Gentry, Lindstrom, Ludwig, Stone, and Zimmerman.

Graduate Faculty, Associate Members: Associate Professors Heist and Pootjes; Assistant Professors Claus, Doty, Karakawa, Tershak, and Zarkower.

Specialized areas of study include microbial physiology, soil microbiology, food and

industrial microbiology, microbial genetics, immunology, bacteriophage, and virology. There is opportunity for cooperative research with other departments in animal disease, food technology, and waste disposal.

Prerequisites for admission are 20 credits in chemistry including quantitative analysis and organic chemistry, 6 in physics, 8 in microbiology, and mathematics through calculus. Admission may be granted with deficiencies up to 8 credits, to be made up while pursuing graduate work. Students who present a 2.80 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

MICROBIOLOGY (MICRB)

401. General Microbiology (4)
407. Problems in Microbiology (1-12)
410. Immunology and Serology (4)
411. Survey of Microbiology (1 per term)
412. The Bacterial Pathogens (4)
413. Soil Microbiology (3)
414. Food Microbiology (4)
415. (V.Sc. 415) Introduction to Animal Viruses (2-4)
416. Industrial Microbiology (4)
417. Epidemiology (2)
418. Bacterial Viruses (4)

507. Seminar (1 per term) Reports on current fields of research.

508. Bacterial Physiology (2-4) Contributions of environment, finestructure, and metabolism to the functioning cell. Prerequisite: Bioch. 402.

511. Special Topics in Microbiology (1-6)

512. Bacteriological Techniques (1-6) Practice in special laboratory techniques including manometry, tissue culture, and serology.

516. Bacterial Genetics (2-4) Mechanisms of variation in microorganisms including mutation, adaptation, sexual recombination, transduction, and transforming factors. Prerequisite: 3 credits each in microbiology and genetics.

520. Biochemical Virology (2) Role of enzymes and nucleic acids in virus synthesis. Regulation of virus reproduction in animal and bacterial cells. Prerequisite: Bioch. 402.

Note: *Microbiology courses offered at The Milton S. Hershey Medical Center are listed on pages 262 and 263.*

MINERAL ECONOMICS (MN EC)

John D. Ridge, *Head of the Department*
101 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professor Ridge, Associate Professor Gordon, Assistant Professor Schenck.

Graduate Faculty, Associate Members: Assistant Professors Harris and Newcomb.

MINERAL ECONOMICS

The program in mineral economics prepares students for careers in mineral industries management, administration, or economic analysis and planning. Students may specialize in such areas as commodity analysis (fuels, metals, or nonmetals); resource economics (mineral policy or area studies); industrial economics (administration, market research, or financial matters); geostatistical and economic analysis of exploration and exploitation problems; or operations research and statistics (resource allocation, forecasting, or decision-making).

Two related but distinctly different general programs for obtaining the M.S. and Ph.D. degrees are available, the one chosen depending on the education and practical experience of the candidate. One program is for students whose background is in the mineral industries and who wish to combine their scientific training with an understanding in depth of the methods by which economics can aid in solving problems in mineral industries exploration, exploitation, and processing. Requirements for admission to this program are 24 credits in chemistry, physics, mathematics, or statistics; 12 in the earth sciences; 9 in economics, mineral economics, commerce, business administration, or industrial management; and 6 in engineering subjects.

The second program is for students whose background is in economics and whose training and experience have given them an interest in applying their economic skills to the solution of mineral industries problems. Requirements for admission to this program are 12 credits in economics, mineral economics, and business administration; 6 in geological sciences; and 9 in mathematics and statistics.

The differences between the programs followed by these two groups of students will affect every aspect of their graduate programs—thesis work, required mineral economics courses, and elective selection. In all cases, the choices among courses and the emphasis within courses taken would be determined by the background of the student, the mineral industries-based program placing equal weight on the technical and economic aspects of mineral economics and the economics-based program placing more weight on the economic than on the technical features of the problems considered.

In addition to the normal degree requirements of the Graduate School, candidates for the M.S. degree must write a thesis and defend it orally. Doctoral candidates in the mineral industries-based program must complete at least 15 credits in economics (including courses used for admission). Doctoral candidates in the economics-based program must complete at least 12 credits in the earth sciences or mineral engineering. The candidacy examination for the doctorate is entirely written, with the exception that the oral examination for the M.S. degree at Penn State may be used as the candidacy examination for the doctorate. If this is done, the M.S. examination will be more detailed and broader in scope than it would be for the M.S. alone. The comprehensive examination for the doctorate includes written examinations in the major and minor fields in addition to the oral examination required by the Graduate School.

Students with deficiencies of 9 credits or fewer in either program may be admitted as degree candidates but will be required to make up such deficiencies without these credits being applicable toward the advanced degree. Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

MINERAL ECONOMICS (MN EC)

400. Seminar (1)
453. Nonmetallic Minerals (3)
483. Economics of the Metals Industries (3)
484. Economics of Energy Resources (3)
486. The Energy Market (3)
490. Mineral Valuation (3)
491. Analysis of Mineral Data (3)

500. Advanced Readings in Mineral Economics (3) Selected readings on topics in mineral history, mineral economics research, applications of economic theory, mineral policy and law, and mineral exploration.

504. Advanced Principles of Mineral Economics (3) Minerals as capital—taxation, conservation, and land tenure; operations of mineral markets; government policy; minerals in world trade and development.

506. Advanced Studies in Mineral Commodities (3) Economic studies of selected mineral commodities and their products. Prerequisite: Mn.Ec. 491.

513. Appraisal of Mineral Resources and Analysis of Exploration Decisions (3) Mineral resource concepts; various quantitative methods for resource evaluation, including computer simulation; exploration economics and decision-making within quantitative frameworks. Prerequisites: Mn.Ec. 490, 491.

522. Technologic Influences (3-9) Relationship of technologic advancements to economic development of the mineral industries. Prerequisite: 3 credits in Mn.Ec. 500.

525. Problems in Mineral Economics (3-12) Individual research involving library, laboratory, or field work to develop solutions to selected techno-economic problems of the mineral industries. Prerequisite: Mn.Ec. 500.

590. Mineral Economics Seminar (1 per term) Preparation and presentation of papers on advanced problems. Required each term in residence.

MINERAL ENGINEERING MANAGEMENT (M E M)

Boris J. Kochanowsky
Chairman of the Committee on Mineral Engineering Management
115 Mineral Industries Building

Degree Conferred: M.Eng.

Graduate Faculty, Senior Members: Professors Aplan, Carpenter, Essenhigh, Given, Griffith, Hummel, Kochanowsky, Lindsay, Miller, Niebel, Ridge, Slobod, Spicer, Stahl, Stefanko, Strong, and Williamson; Associate Professors Farouq-Ali, Healy, and Lovell; Assistant Professor Schenck.

Graduate Faculty, Associate Members: Associate Professors Guild and Raphael, Assistant Professor Harris.

This program educates engineers for advancement into executive production management positions in the mineral and heavy construction industries, in development and sales in manufacturing companies, and in consulting firms. It is designed to provide the knowledge, skills, and attitudes needed by persons to become innovators and responsible decision-making leaders. Participants are trained to create new designs, systems, and methods, and to plan, develop, and lead mineral industry organizations.

The content of all courses is based upon specific problems encountered in the mineral industries. These courses are offered by departments which have combined their resources to offer this interdisciplinary effort, namely: Departments of Mining, Petroleum and Natural Gas, Mineral Preparation, Mineral Economics, Materials Science, and Industrial Engineering. Courses in each area may be selected by students

and adapted to their individual interests. Seminars on integrated management problem solving are an essential feature of this program.

Programs emphasize quantitative methods (statistics, operations research, and computer applications); principles of economics applied in mineral industries (mineral economics, mineral commodities, cost and investment analysis, economic feasibility and profitability analysis, analysis involving intangibles); and management (finance marketing, industrial, public, and labor relations, production, and operation management).

Students are required to present a scholarly written report on developmental study topics which may be suggested by industry.

For admission a bachelor's degree in one of six engineering branches of mineral industry (mining, petroleum, mineral preparation, metallurgy, fuel, and ceramics) or some other closely related field (industrial, civil, geological, mechanical, or chemical engineering) is required. The program will differ according to the specific goals of these branches and will be adapted to meet professional requirements. Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

MINERAL ENGINEERING MANAGEMENT (M E M)

510. Production and Operations Management (3-9) Over-all planning, design, and selection of equipment; programming and scheduling of mining operations; statistical control of costs and production indices.

MINERAL PREPARATION (MN PR)

Frank F. Aplan, *Head of the Department*
4 Mineral Sciences Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Aplan, Spicer, and Sun; Associate Professor Lovell.

The graduate program in mineral preparation not only prepares the student for a career in research or education but is also designed to give him the additional training needed to effectively pursue an industrial career as a specialist in mineral preparation methods. The mineral preparation engineer is concerned with the separation of valuable minerals from worthless rock by physical and chemical means as well as with the application of these methods to the recycle processing of used metals and minerals. He is also vitally interested in the control of air, land, and water pollution—particularly as they relate to mineral raw materials.

The student studies the physics and chemistry of particles—their creation, characterization, separation, and agglomeration; the surface chemistry of mineral particles; and chemical separations. This specialized knowledge is then integrated with the pertinent knowledge from the geological sciences to provide the basis for developing and understanding the practical means of separation of valuable material from that which is worthless.

Graduates with bachelor's degrees in ceramics, chemistry, chemical engineering, fuel science, the geological sciences, mathematics, metallurgy, mining, physics, or some branch of engineering are eligible for admission. Students with deficiencies may be required to make them up concurrently with their graduate studies. Students who present a 2.50 junior-senior average will be acceptable to the department provided

they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

MINERAL PREPARATION (MN PR)

401. Advanced Mineral Preparation Laboratory (1)
402. Mineral Preparation Seminar (1)
410. Coal Preparation (3)
420. Principles of Mineral Preparation Unit Operations I (3)
421. Principles of Mineral Preparation Unit Operations II (3)
425. Principles of Flotation (3)
426. Flotation Laboratory (1)
427. Modern Processes in Mineral Preparation (3)
430. Flowsheets of Mineral Preparation Plants (3)
457. Field Trip (1-2)

502. Froth Flotation and Agglomeration (3) Intensive study of theory and applications of froth flotation and agglomeration. Prerequisite: Mn.Pr. 420. *Mr. Sun*

504. Mineral Preparation Research (1-6 per term) Research work and study on specific problems in mineral preparation. Prerequisite: Mn.Pr. 410 or 420. *Staff*

505. Gravity Processes and Miscellaneous Methods of Mineral Preparation (3) Intensive study of theory and applications of gravity, magnetic, electrostatic, centrifugal, and dense-media processes of mineral concentration. Prerequisite: Mn.Pr. 420. *Mr. Spicer*

506. Mineral Preparation Plant Design (3-10) Layout, design, and selection of equipment for specific mineral preparation plant projects. Prerequisite: Mn.Pr. 420. *Mr. Spicer*

507. Chemical Processes of Mineral Preparation (3) Practice and theory of methods to upgrade ores by chemical treatment including roasting, solubility separations, surface phenomena, and reactions. Prerequisite: Mn.Pr. 420. *Staff*

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in mineral preparation studies are listed under Materials Science.*

MINERALOGY AND PETROLOGY (MIN P)

Arnulf Muan
Head of the Department of Geochemistry and Mineralogy
204 Deike Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Barnes, Bates, Brindley, Burnham, Greig, Griffiths, Keith, Muan, Osborn, Roy, Wickman, and Wright; Associate Professors Dachille, Newnham, Smith, Thornton, and White; Mrs. Roy; Assistant Professor Suhr.

Graduate Faculty, Associate Members: Associate Professor Rose; Assistant Professors Boettcher, Deines, and Langmuir.

MINERALOGY AND PETROLOGY

Areas of specialization include igneous, sedimentary, and metamorphic petrology, experimental petrology, mineralogy, crystallography, crystal chemistry, X-ray mineralogy, clay mineralogy, ore mineralogy, and application of statistics in the earth sciences.

The general requirements for admission are mathematics through integral calculus; chemistry through quantitative analysis; 10 credits in general physics; and 30 credits in geology, petrology, and mineralogy including microscopical petrography. Additional specific requirements must be fulfilled in most areas of specialization.

Students who have taken somewhat less than the indicated minimum of subjects may be admitted but must make up their deficiencies concurrently with their graduate studies. Students who present a 2.70 average in their basic science and geoscience subjects will be considered by the department subject to the limitations of facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

The no-thesis option is available for the M.S. degree.

MINERALOGY (MIN)

400. (Cer.Sc. 400) Nonmetallic Crystal Chemistry (2) *Mr. Brindley*
402. Mineralogy and Petrology for Teachers (3) *Mr. Thornton*
411. (Mat.Sc. 411) Instrumental Techniques Applied to Materials and Mineral Science Problems (1-4)
Unit A. X-ray Diffraction
Unit B. Electron Microscopy
Unit C. Spectroscopy
Unit D. Electron Probe Analysis
413. Scientific Method Applied to the Earth Sciences (3) *Mr. Griffiths*
421. (Mat.Sci. 421) X-Ray Diffraction (3)
431. (Mat.Sc. 431) Instrumentation for Physical Measurement and Control (3)
450. Volcanology (3)
463. Optical Mineralogy (3) *Mr. Kerrick*
483. Petrology (3) *Mr. Thornton*
484. Petrology (2) *Mr. Griffiths*
490. Petrographic Problems (1)

500. Optical Crystallography of Materials (3) Optical methods, microscopic techniques, and measurement of optical constants of crystals; theory and application of the universal stage. Prerequisite: Min. 463. *Mr. Wright*

501. Petrology (3-6) Microscopic study of rocks, emphasizing classification and genetic relationships.

502. Mineralogical Problems (3) Original study of some limited mineralogical or petrological problems.

505. Mineralogy Seminar (1-2) Reading, presentation, and discussion of literature dealing with various phases of theoretical mineralogy. Topics are selected to meet the interests of the majority of the students.

*510. Metamorphic Petrology (2-6) Detailed review of chemical, mineralogical, and structural changes that take place during metamorphism. Prerequisites: Min. 483, 484. *Mr. Burnham*

513. Scientific Method in Geoscience (3) Problem formulation, sampling designs, selection of variates, and comparison of techniques for analysis of aggregates. *Mr. Griffiths*

* Credits to be arranged, 2-4 per term.

514. Statistical and Electronic Data Processing Procedures for Geoscience (3) Statistical analysis of experimental data using univariate and bivariate procedures.

520. Study of Accessory Minerals (2-4) Detailed study of accessory (heavy) minerals; their significance in problems of provenance, petrogenesis, mineral stratigraphy, and paleogeography. Prerequisites: Min. 511, 513, 514.

525. Igneous Petrology (2-6) Origin, distribution, and composition of igneous rocks. Prerequisites: Gchem. 513; Min. 483, 484, 500, 527. *Mr. Burnham*

526. Problem-Solving in Geoscience (3) Multivariate statistical analysis, decision-making, operations research, and systems analysis in geoscience. *Mr. Griffiths*

527. Igneous and Metamorphic Mineralogy (3) Structural and compositional variations of minerals in igneous and metamorphic rocks.

530. (Cer.Sc. 530) Structure, Properties, and Occurrence of Clay Minerals (2-5) Structure analysis and identification of clay minerals; mineral transformations and behavior; occurrence, genesis, and petrography of fine-grained sediments. *Mr. Brindley*

531. (Mat.Sc. 531) Electron Transmission Microscopy in the Materials and Mineral Sciences (3) Discussion of electron image contrast theory as a tool for study of atomic substructures in the materials and mineral sciences.

532. (Mat.Sc. 532) Structure Analysis (2) Crystal structure determination methods: space groups, structure factors, heavy atoms and isomorphous replacement, Fourier synthesis, Patterson maps, inequalities, refinement techniques. Prerequisite: Mat.Sc. (Min.) 421.

533. (Mat.Sc. 533) Single Crystal Methods (2) Experimental techniques in crystal structure determination: crystal selection, space group determination, measurement of intensities, analysis of data. Prerequisite: Mat.Sc. 421 or Min. 421.

535. (Mat.Sc. 535) Geometrical Crystallography (2) Derivation of lattices, types, point groups and space groups with applications.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in mineralogical studies are listed under Materials Science.*

MINING ENGINEERING (MNG E)

Thomas V. Falkie, *Head of the Department of Mining*
118 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Kochanowsky and Stefanko, Associate Professor Hardy, Assistant Professor Voight.

Graduate Faculty, Associate Member: Assistant Professor Manula.

Areas of specialization which may be followed in research and course work include mine property valuation and economics of mining engineering (ore estimation, cost analysis and control, budgeting), mechanization and mine plant (unit operations, materials handling, continuous mining, power supply), development and exploitation methods (mine planning and layout, design of systems), mine management, produc-

tion engineering and operations research (time study, standards, job rating, operations analysis), environmental control (gas and dust technology, ventilation, air conditioning, hygiene, illumination, safety), and rock mechanics (stress analysis, roof and ground control, penetration, fragmentation).

A bachelor's degree in mining engineering or a related engineering field is required for admission. Students may be required to make up deficiencies in their area of specialization. Certain basic, related courses outside the department may be approved as part of the major. Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

MINING (MNG)

402. Mine Plant Design (3)
410. Mining Engineering Analysis (3)
411. Mine Systems Engineering (3)
422. Mine Ventilation and Air Conditioning (3)
431. Rock Mechanics (3)
451-452. Advanced Mining Engineering I and II (1 each)

513. Mine Cost Analysis (3) Nature of mining costs, their analysis and control: depreciation and depletion, capital and operating costs, budgets, records.

514. Mine Operations Analysis (3) Application of operations research techniques in determining optimal design and operating policies for mine management. Prerequisite: Mng. 411.

515. Mine Systems Simulation (3) Principles and practices of probabilistic and deterministic simulation in the analysis of operating systems related to mills and mines. Prerequisites: Mng. 411, Cmp.Sc. 401.

531. Rheological and Strength Characteristics of Rocks (3) Properties of rocks and their determination; failure theories; brittle to ductile transition; rheological behavior. Prerequisite: Mng. 431.

532. Special Topics in Rock Mechanics (1-3) Behavior of rock under static loading; underground stress instrumentation; experimental stress analysis; design of mine openings; theories of subsidence.

533. Post-Yield Mechanics of Rock (3) Theory of inelastic, time-independent rock behavior; selected applications to drilling, blasting, mine opening, pit slopes, and ore passes. Prerequisite: Mng. 431.

541. Theory of Rock Penetration (3) Behavior of rock under dynamic loads intended to penetrate; basic energy relations; application of theory to drilling and other penetration. Prerequisites: E.Mch. 13, Mng. 30, Phys. 203.

542. Theory of Rock Fragmentation (3) Behavior of rock under dynamic loads intended to fragment; physical chemistry of explosives; detonation; theory of blasting; design of drill rounds. Prerequisites: E.Mch. 13, Mng. 30, Phys. 203.

543. Strata Control Engineering (3) Theoretical considerations; convergence, abutments, subsidence; rockbursts; underground support systems; design of mine openings. Prerequisite: Mng. 431.

545. Rock Mechanics Instrumentation (3) Strain gage circuitry, transducers, electro-hydraulic servo installations, and integrated strain and force measuring systems as applied to rock mechanics. Prerequisite: Mng. 431.

580. Mining Engineering Research (1-3 per term) Supervised research on a specific problem involved in mining science or technology.

590. Graduate Mining Seminar (1 per term) Preparation and presentation of formal papers on problems of an advanced nature in mining engineering. Required once during each year of residence.

MUSIC (MUSIC)

Robert W. Baisley, *Head of the Department*
232 Music Building

Degrees Conferred: M.A., M.F.A.

Graduate Faculty, Senior Member: Assistant Professor Brinsmaid.

Graduate Faculty, Associate Members: Professors Baisley and Wild, Assistant Professor Case.

The Master of Arts degree program is designed to provide a wide range of studies in music. The student may emphasize one of the following areas, or may elect a program including work in all of them: theory, performance, history, and composition. Admission requires completion of a recognized music major. A thesis is required of all M.A. candidates in the program.

The Master of Fine Arts degree program is planned to provide professional emphasis. Students will specialize in either performance or composition. In addition to credit requirements, admission to the program is contingent upon department certification of the candidate's competence. According to the area of specialization, auditions or submission of manuscripts are required. Arrangements for this can be made by the student with the department. While 48 credits are listed as a minimum requirement, it should be noted that the amount of course work necessary may exceed the minimum according to the needs and background of the student involved.

Students who lack the recommended upper-class courses in music may be required to take additional course work without receiving graduate credit.

The department sponsors musical activities, and candidates for both degrees are required to participate in positions of responsibility.

Students who present a 2.50 junior-senior average will be acceptable to the department provided they have adequate musical ability and training, subject to limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

MUSIC (MUSIC)

407. Piano Literature (3)
410. Music of the 20th Century (3)
411. A Chronological Study of String Literature (3)
412. Music of the Baroque Period (3)
413. Music of the Middle Ages (3)
414. Music of the Renaissance (3)
415. Hymnology (3)
416. Studies in American Music (3)
*‡429. Vocal Style (3) Fee $80.
433. The Singing Voice (3)
454. Harmonic Analysis (3)

* Course may be scheduled only by conference with the head of the department.
‡ May be repeated for a total of 18 credits.

455. Form and Analysis (3)
456. Counterpoint (3)
457. Composition (3)
459. Orchestration and Arranging (3)
466. Advanced Conducting (3)
467. Opera Workshop (1-6)
468. Advanced Chamber Music (1-6)

*‡501. Advanced Harpsichord (3) Instruction in harpsichord playing; preparation for recital performance. Fee $100.

*‡503. Advanced Orchestral Instruments (3) Study, repertoire building, and recital performance. Fee $80.

*‡511. Advanced Piano (3) Piano literature of all periods for public performance. Fee $80.

*‡520. Voice (3) Study, repertoire building, and recital performance. Fee $80.

*‡531. Advanced Organ (3) Study, repertoire building, and recital performance. Prerequisite: 4 credits of Music 31 and/or 38. Fee $100.

543. Modern Harmony (3) Harmonic writing based on 20th century practices with attention to traditional idioms that serve as foundation.

544. Analysis and Analytic Procedures (3) Analytic studies for the development of effective understanding of modern musical syntax.

557. Symphonic Structure (3) Survey of the evolution and application of the forms used in symphony, sonata, concerto, string quartet, and related works. Prerequisite: Music 369.

*‡558. Free Composition (3) Composition: vocal and instrumental, standard or modern idioms.

567. The Literature of the Orchestra (3) The suite, symphony, tone poem, and overture from the point of view of appreciation, form, and orchestration.

570. History of Musical Instruments (3) A survey of the historical and morphological aspects of musical instruments.

571. Performance Practices (3) Analysis and performance of music of various periods based on manuscripts, documents, and other source materials.

598. Music Seminar (1-3) Seminar in the history, art, and science of music, with readings, discussion, and performance.

MUSIC EDUCATION (MU ED)

Frances M. Andrews, *Head of the Department*
266 Chambers Building

Degrees Conferred: D.Ed., M.Ed.

Graduate Faculty, Senior Members: Professors Andrews and Dunlop.
Graduate Faculty, Associate Members: Professor Campbell, Assistant Professor Deihl.

Graduate programs offer work in the various areas of public school music, including

general, instrumental, and vocal/choral music on the elementary and secondary levels; preparation is also offered for supervisory or administrative positions, college teaching, and research. It is possible to include work from a number of these areas in the M.Ed. or D.Ed. program.

Completion of a recognized music education major, or program leading to certification, is a prerequisite for admission to the M.Ed. or D.Ed. program. The latter also requires a minimum of two years of teaching experience.

Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and can demonstrate musical proficiency, subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

MUSIC EDUCATION (MU ED)

415. Workshop in Selected Music Education Studies (1-6)
446. The Elementary Music Specialist (3)
468. The Teaching of Piano (3)
469. Band and Orchestra Technique (3)
470. Choral Technique (3)
471. Teaching Marching Band (3)
472. Wind Instrument Materials (3)
473. Psychological Foundations of Musical Behavior (3)
474. Tests and Measurements in Music (3)
475. Objectives and Problems in Elementary Music Education (3)
480. Choral Program in the Secondary School (3)
487. Children's Songs and Records (3)

500. Music Education Seminar (3-6) Problems of various phases of music education, both instrumental and vocal; research and literature dealing with these problems.

501. Problems and Projects in Music Education (1-6) Independent work on special topics of music education pertinent to the development of curricula, methods, and materials in music education. Prerequisite: 12 graduate credits in education (including music education).

525. Proseminar: Graduate Study in Music Education (1-3) Bibliography; location and evaluation of reference materials; organization, form, style in preparing music education research reports and other papers.

555. Research Methods in Music Education (3-6) Research methods and designs for problems in music education; techniques for studying cognitive, affective, and psychomotor responses to musical stimuli. Prerequisites: Mu.Ed. 525, Ed.Psy. 406 or 407, 475.

569. Present-Day Trends in Instrumental Music (3-6) New methods and materials for band, orchestra, and ensembles.

572. Instrumental Pedagogy (3-6) Research problems in band and orchestra. Prerequisite: Mu.Ed. 54 or practical experience.

573. The Materials of Appreciation (3) Examination of written and recorded materials and appropriate techniques for developing appreciation of music, grades one through twelve.

574. Present-Day Trends in Music Education (3-6) Present-day music education materials and methods (elementary and secondary levels) in relation to modern educational philosophy; emphasis on practical problems presented by members of the class. Prerequisites: Mu.Ed. 48, teaching experience.

MUSIC EDUCATION

575. The Junior High School Music Curriculum (3) Instructional materials, procedures, curricular and extracurricular activities, integration with other subjects.

576. Music Supervision (3) Current educational procedures in training music supervisors.

581. Contemporary Music Education (3) Prerequisite: 20 credits at the graduate level including Mu.Ed. 500.

582. Theory and Projects in Musical Learning (3-6) Experimentation and self-instructional techniques involved in musical learning projects. Prerequisite: Inst.M. 435.

594. Pedagogy of Music Theory, Reading, and Ear Training (3) Instructional theory and materials basic to teaching music theory, reading, and ear training. Musical instruments, audio-visual devices as aids. Prerequisite: 12 credits in music theory and/or harmony.

598. Internship in Music Performance Techniques (1-6) Internship in selected school or music performance situations other than those in the district where the graduate student is employed.

NUCLEAR ENGINEERING (NUC E)

Warren F. Witzig, *Head of the Department*
231 Sackett Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty, Senior Members: Professors Diethorn, Foderaro, Jacobs, Palladino, Schultz, and Witzig; Associate Professors Kenney, Klevans, and Remick.
Graduate Faculty, Associate Members: Assistant Professors D'Ardenne and Jester.

Fields of study are individually tailored, and engineering is emphasized through the study of reactor physics—computational methods, transport theory, and nuclear design; plasma physics—waves, analysis, and fusion laboratory; shielding—Monte Carlo methods and two-body kinematics; reactor systems design—thermal, mechanical, and control; reactor fuels—configuration, radiation effects, and fuel cycle management; isotope utilization—activation analysis, chemical processes including copolymerization and nuclear medicine; plowshare applications; safety analysis—reactor siting, engineered safeguards, and nonlinear kinetics. The department offers three degrees at the Master's level: an M.S. with paper, an M.S. with thesis, and an M.Eng.

Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

NUCLEAR ENGINEERING (NUC E)

400. Nuclear Engineering Special Topics (1-12)
401. Introduction to Nuclear Engineering (3)
405. Nuclear and Atomic Properties of Matter (3)
407. Statistical and Transport Descriptions of Matter (3)
410-411. Nuclear Engineering (3 each)
415. Radionuclear Applications (3)
420. Radiological Safety (2)

430. Design Principles of Reactor Systems (3)
431. Synthesis of Nuclear Systems (2)
440-441. Nuclear Engineering Laboratory (3 each)
490. (E.E. 490) Introduction to Plasma Theory (3)

501. Reactor Engineering (3) Reactor controls, shielding of nuclear reactors, stress analysis of reactor materials, power cycle analysis, breeding, and advanced design considerations. Prerequisite or concurrent: Nuc.E. 411.

502. Reactor Engineering Laboratory (1-5) Reactor experiments devised to acquaint the student with reactor technology. Prerequisite or concurrent: Nuc.E. 411.

503. Thermonuclear Engineering (3) Binary fusion reactions; microscopic and macroscopic phenomena in a completely ionized gas; electromagnetic confinement; design, operation, and diagnostics of experiments. Prerequisite: Math. 452.

505. Reactor Instrumentation and Control (3) Neutron-detecting instruments and circuits; in-core power instrumentation; reactor control principles; control mechanisms; operational control problems. Prerequisite: Nuc.E. 411.

506. Two-Body Kinematics (3) Conservation laws of classical and quantum mechanics and their application to interactions between two bodies. Prerequisite: Math. 72.

507. Interaction of Radiations with Matter (3) Theory of the processes by which gamma rays, neutrons, and charged particles interact with electrons, atoms, and nuclei. Prerequisite: Nuc.E. 506.

508. Radiation Shielding (2) Radiation sources in reactor systems; attenuation of gamma rays and neutrons; deep penetration theories; Monte Carlo methods. Prerequisite: Nuc.E. 507.

509. Radiation Damage in Solids (2) Production of defects by high energy particles; nature of defects; diffusion and annealing in solids; macro property changes. Prerequisite: Nuc.E. 507.

511. Nuclear Reactor Materials (3) Philosophy, selection, technology, use, economics, and performance of materials of major interest in nuclear power reactors today. Prerequisite: Nuc.E. 411.

520. Reactor Analysis (3) Physical principles and mathematical methods of reactor analysis. Prerequisite: Nuc.E. 410.

521-522. Neutron Transport Theory (3 each) Derivation of Boltzmann equation for neutron transport; techniques of approximate and exact solution for the monoenergetic and spectrum regenerating cases. Prerequisite: Nuc.E. 410 or Phys. 406.

525. Nonlinear Reactor Kinetics (3) Intrinsic response of reactors to extreme reactivity insertions, mathematical models, physics of feedback coefficients, analysis of behavior of burst reactors. Prerequisite: Nuc.E. 411.

550. Special Topics in Nuclear Engineering (1-12) Theoretical studies in nuclear engineering with or without associated experimental work. Prerequisites: Math. 72, Phys. 406.

590. (E.E. 590) Theory of Plasma Waves (3) Solutions of the Boltzmann equation; waves in bounded and unbounded plasmas; radiation and scattering from plasmas. Prerequisite: Nuc.E. 490.

591. (E.E. 591) Plasma Theory (3) Advanced topics in kinetic theory, fluctuation theory, microinstability, and turbulence. Prerequisite: Nuc.E. 590.

PETROLEUM AND NATURAL GAS ENGINEERING (PNG E)

C. Drew Stahl
Head of the Department of Petroleum and Natural Gas
25 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Slobod and Stahl; Associate Professors Bissey, Burcik, and Farouq-Ali.

Graduate Faculty, Associate Member: Associate Professor Donohue.

Areas of specialization include experimental and theoretical studies of water flooding and the newer methods for displacing oil from porous media, methods for calculating reservoir performance, scaled laboratory studies of reservoir phenomena, and drilling and well completion problems.

Students who expect to enter graduate study in this field with a degree in another major should present 6 credits in geology, 15 in engineering science, and credit for mathematics through integral calculus. A limited number of deficiencies may be made up after admission. Certain closely related courses outside the department may be counted as petroleum and natural gas credits toward the degree.

Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

PETROLEUM AND NATURAL GAS (P N G)

400. Thesis (1-6)
410. Applied Reservoir Engineering (3)
420. Applied Reservoir Analysis (3)
421. Reservoir Engineering (3)
450. Drilling Design and Production Engineering (3)
475. Petroleum Engineering Design (3)
480. Production Process Engineering (3)
481. Natural Gas and Gasoline Plants (2)
485. Engineering in Secondary Recovery (3)
493. Engineering Evaluation of Oil and Gas Properties (3)
495. Formation Evaluation (3)

510. Flow of Homogeneous Fluids Through Porous Media (3) Applications of vectors, separation of variables, conformal mapping, Laplace transform to describe steady and unsteady state flow in porous media.

511. Material Transfer in Porous Media (3) Diffusion and convective mixing in porous media; solution of the partial differential equations involved; difference methods; mathematical model, viscous instabilities.

512. Reservoir Engineering (3-6) Mathematical analysis of complex reservoir behavior and combination drives; numerical methods for the solution of behavior equations; recent developments. Prerequisite: P.N.G. 510.

514. Optimization of Petroleum Recovery Processes (3) Optimum search methods, linear programming, nonlinear programming, dynamic programming, application to waterflooding, depletion drive, steam injection, gas cycling, miscible displacement. Prerequisite: P.N.G. 410.

515. Advanced Oil Recovery Techniques (3) Advanced oil recovery techniques including water-flooding, in-situ combustion, steam injection, hot-water injection, and miscible-phase displacement.

517. Case Studies of Secondary Recovery (1-3) Interpretation and critical analysis of production and injection characteristics of typical water flood operations. Prerequisite: P.N.G. 515 or 485.

519. Design of Thermal Recovery Projects (3) Suitability of reservoirs for thermal oil recovery; case histories; design of in-situ combustion and steamfloods; thermal stimulation; shale oil recovery. Prerequisite: P.N.G. 515.

520. Phase Relations in Reservoir Engineering (3) Phase relations as applied to condensate and retrograde condensate reservoirs and to other problems in petroleum production.

525. Special Topics in Petroleum Engineering (2-6)

530. Natural Gas Engineering (1-3) Flow in producing or storage reservoirs; gas well testing; transmission systems; storage cycle; current developments. Prerequisite: P.N.G. 481.

*535. Seminar (1-3)

540. Special Studies in Petroleum Engineering (1-3) Supervised short study performed in the field, library, or laboratory covering any approved topic related to petroleum engineering.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in petroleum and natural gas studies are listed under Materials Science.*

PHARMACOLOGY (PHARM)

Elliot S. Vesell, *Chairman of the Department*
The Milton S. Hershey Medical Center

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professor Vesell, Associate Professors Fritz and Greene.

Graduate Faculty, Associate Members: Assistant Professors Conner and Severs.

The department offers opportunities for research and courses in drug metabolism, endocrine pharmacology, neuropharmacology, cardiovascular pharmacology, clinical pharmacology, and general pharmacology. Emphasis is placed on molecular and physiological mechanisms by which drugs act in the body and by which the body transforms drugs.

A bachelor's degree reflecting a reasonable background in zoology or biology, mathematics, and chemistry is required; reading knowledge of one or two foreign languages is recommended, but not required. Applicants must provide complete tran-

* Credits to be arranged, 1 per term.

scripts and two letters of recommendation. Scores from the Graduate Record Examination and a personal interview are desirable. Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

This program is offered only at The Milton S. Hershey Medical Center.

PHILOSOPHY (PHIL)

CARL R. HAUSMAN
In Charge of Graduate Programs in Philosophy
247 Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty, Senior Members: Professors Anderson, Freund, Hausman, Johnstone, Kockelmans, and Rosen; Associate Professors Gotshalk and Lingis.

Graduate Faculty, Associate Members: Associate Professors Price and Tsugawa; Assistant Professors Caton, Flay, Kennington, and Vaught.

A thorough grounding in the history of philosophy is desirable for all students. Specialization is possible in areas (such as aesthetics, metaphysics, ethics, social philosophy, logic, and history and philosophy of science); in movements of thought (such as rationalism, empiricism, idealism, phenomenology, and existentialism); or in any of the major figures in the history of western philosophy. Specialization is also possible in a joint program with the Department of Mathematics in logic and the foundations of mathematics. Undergraduate preparation to the extent of a strong minor is advisable. The department may waive the requirement of a thesis for an M.A. candidate.

Students who present a 3.00 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

PHILOSOPHY (PHIL)

406. MEDIEVAL PHILOSOPHY (3)
408. STUDIES IN SOCIAL AND POLITICAL PHILOSOPHY (3)
410. STUDIES IN GREEK PHILOSOPHY (3-6)
411. STUDIES IN MODERN PHILOSOPHY (3-6)
412. STUDIES IN CONTEMPORARY PHILOSOPHY (3)
413. PHILOSOPHY OF LITERATURE (3)
414. AESTHETIC THEORY (3)
417. NINETEENTH CENTURY PHILOSOPHY (3)
419. PHILOSOPHICAL BACKGROUNDS OF AMERICAN THOUGHT (3)
420. PHILOSOPHY OF HISTORY (3)
421. CLASSICS OF SCIENTIFIC METHODS (3)
422. PHILOSOPHICAL LOGIC (3)
424. STUDIES IN PHILOSOPHY OF RELIGION (3)
426. METAPHYSICS (3)
427. ADVANCED ETHICS (3)
428. (Math. 428) LOGICAL THEORY (3)
429. SEMANTICS: PHILOSOPHY OF LANGUAGE AND SYMBOLISM (3)
430. PHILOSOPHICAL PROBLEMS (1-9)

435. Religion and Science (3)

500. Ethics: Historical and Systematic (2-6) Critical study of some phase of ethical theory, or of some period of the history of ethics.

504. Social and Political Philosophy (3-6) Critical study of basic problems in their historical and functional setting.

505. Philosophy of Western Religion (3-6) The consideration of contemporary western religious concepts in terms of their Graeco-Judean traditions.

506. Seminar in Ancient Philosophy (3-6) Study of one or more important men or movements in ancient philosophy.

507. Seminar in Medieval Philosophy (3-6) Study of one or more important men or movements in medieval philosophy.

508. Seminar in Modern Philosophy (3-6) Men and movements in philosophy from the Renaissance through the 19th century.

509. Seminar in Contemporary Philosophy (3-6) Men and movements in 20th century philosophy.

511. Principles of Experimental Inference (3-6) Science as controlled inquiry; types of scientific procedures in formal, physical, and sociocultural science.

512. Advanced Topics in Philosophy of Science (3-6) Crucial problems in the theory of science and scientific method.

514. Seminar in 19th Century Philosophy (3-6) Study of a philosopher or philosophical movement of the 19th century.

515. Philosophical Method (3-6) Methods proposed by classical and contemporary thinkers for reaching philosophical conclusions: deductive, inductive, dialectical, pragmatic, intuitive.

516. Seminar in Aesthetics (3-6) Problems and theories in the nature of art.

526. Seminar in Metaphysics (3-6) Formulation and analysis of metaphysical problems in the various fields of philosophy.

530. Philosophy Research Seminar (1-12) Study of selected philosophical problems with an emphasis on techniques of philosophical research.

550-551. (Math. 550-551) Foundations of Mathematical Logic (3 each) The nature of logical basis of mathematics; critical examination and development of the basic parts of logical calculus. Prerequisite: Math. 480 or Phil. 428.

554. (Math. 554) Logic and Metamathematics I (3) Completeness, Löwenheim-Skolem, Herbrand, and compactness theorems; first-order theories; categoricity, elimination of descriptions; decidability; algebraic and geometric applications. Prerequisite: Phil. 428.

556. (Math. 556) Recursion Theory (3) Recursive functions; normal form, enumeration and separation theorems; partial recursive functions; recursion theorems; special recursive functions; alternate formulations; related topics. Prerequisite. Phil. 428.

557. (Math. 557) Logic and Metamathematics II (3) Arithmetization; Gödel and Tarski incompleteness theorems; undecidability results; Gentzen-type systems and consistency results. Prerequisite: Phil. 554, 556.

PHYSICAL EDUCATION (PH ED)

RICHARD C. NELSON, *Head of the Department*
270 Recreation Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors Buskirk, Conger, Coombs, Gross, Harnett, Mendez, Thiel, and van der Smissen; Associate Professor Nelson.

Graduate Faculty, Associate Members: Associate Professors Kollias, Lucas, Lundegren, Magnusson, and Nicholas; Assistant Professors Morehouse and Skinner.

Areas of specialization include (1) physiology of exercise (physical conditioning, physical fitness, and performance stress); (2) kinesiology (applied anatomy and biomechanics); (3) measurement and test construction; (4) cultural bases of physical education and sport (history, philosophy, and sociological foundations); (5) motor learning; (6) organization and administration (methods and materials, curriculum construction, intramurals, and interscholastics); and (7) recreation and parks.

Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

Admission to the M.S. program requires a major in physical education or its equivalent in comparable course work. Especially desirable is course work in mathematics plus a concentration on the physical, biological, behavioral, or social sciences, depending upon the intended areas of specialization. Admission to the M.Ed. program requires a minimum of 18 credits in health and physical education plus 18 credits in education and educational psychology combined, including practice teaching. A year or more of field experience is recommended.

Admission to doctoral study requires the master's degree or its equivalent, demonstrated research ability in the form of a thesis or published research, and acceptable performance on the Aptitude Test of the Graduate Record Examination or other specified tests. A student who has earned a master's degree in recreation and parks and meets the above requirements may enter a doctoral program in physical education with specialization in recreation and parks.

See also "Recreation and Parks."

HEALTH EDUCATION (HL ED)

411. PRINCIPLES AND METHODS OF TEACHING SAFETY EDUCATION (3)
456. ADVANCED TECHNIQUES IN SCHOOL COMMUNITY HEALTH EDUCATION (3)
498. SPECIAL PROJECTS (1-6)

501. HEALTH IMPLICATIONS IN THE GROWTH AND DEVELOPMENT OF SCHOOL CHILDREN (3) Child growth and development emphasis for teachers; medical inspection and examination; preschool program; early habit formations; behavior problems; cooperation of parents, teachers, and children. Prerequisite: Hl.Ed. 215.

PHYSICAL EDUCATION (PH ED)

400. ADAPTIVE PHYSICAL EDUCATION (3)
452. ANALYSIS OF PHYSICAL EDUCATION ACTIVITIES FOR THE ELEMENTARY SCHOOL (3)
455. STATISTICAL METHODS IN HEALTH, PHYSICAL EDUCATION, AND RECREATION (3)
456. PHYSICAL FITNESS APPRAISAL (3)
460. METHODS AND PRINCIPLES OF ATHLETIC COACHING (3)

480. Advanced Anatomy and Physiology, Applied (3)
483. Principles of Body Mechanics (3)
484. Kinesiology (3)
489. Intramural Athletics (3)
490. Introduction to Tests and Measurements in Health and Physical Education (3)
491. Organization and Administration of Health and Physical Education in Schools (3)
495. History of Sport in American Society (3)

500. (Rc.Pk. 500) Individual Study and Research Projects (1-10) Prerequisite: Ph.Ed. 530.

530. (Rc.Pk. 530) Research Techniques in Health and Physical Education and Recreation (3)

531. Research in Health and Physical Education and Recreation (3) Prerequisite: Ph.Ed. 530.

532. Tests and Measurements in Physical Education (3) Critical study of tests and measurements available in physical education; methods of constructing and evaluating new tests and measurements. Prerequisite: Ph.Ed. 490.

534. Studies in Curriculum Construction in Physical Education (3) Principles and methods of curriculum building in physical education; different psychological and educational points of view, organizing a course of study committee, making units of instruction.

535. Modern Foreign Systems of Physical Education (3) Comparative analysis of national and local programs and systems of physical education in foreign countries. Prerequisites: Ph.Ed. 534, 595.

550. Seminar in Health and Physical Education (1-6) An in-depth analysis of current problems confronting the profession.

560. Administrative Problems of Physical Education in Schools (3) Solutions to problems emerging from the administration of physical education in schools, fitting physical education in the school's schedule, awards and budgets. Prerequisite: Ph.Ed. 491.

565. Neuromuscular Performance (3) Integrative action of the neural and muscular systems in effecting human movement with emphasis on motor performance. Prerequisites: Ph.Ed. 480, 490.

575. Motor Performance of the Handicapped (3) Motor performance of physically handicapped and mentally retarded. Activities and therapeutic exercises for the formulation of individualized programs. Prerequisites: Ed.Ser. 409, E.E.C. 410.

576. Internship in Adapted Physical Education (3) Supervised internship in recreational, educational, or clinical situations; assessment of motor performances, evaluation of activities, and staff conference participation.

581. Biomechanics (3) Kinetic and kinematic analyses of human motion utilizing electromyography and stroboscopic-photographic techniques. Prerequisite: Ph.Ed. 480.

582. Advanced Kinesiology (3) Analysis of sports movements utilizing cinematography, electronic devices, and related research instruments.

583. Special Topics in Biomechanics (1-6) Critical review of current research in biomechanics, culminating in individual research projects. Prerequisite: Ph.Ed. 581 or 582.

585. (Phsio. 585) Applied Physiology (3) Presentation of current thinking on physiological mechanisms with emphasis on physically active man. Prerequisite: 3 credits in physiology at the 400 or 500 level.

586. (Phsio. 586) Research Methods in Applied Physiology (3) Historical and current procedures for evaluation of cardio-pulmonary function, metabolism, and thermal balance in man; lecture, demonstration, and student laboratory. Prerequisite: 3 credits in physiology at the 400 or 500 level.

588. (Phsio. 588) Special Topics in Applied Physiology (1-6) Critical discussion and evaluation of current research in applied physiology. Prerequisite: Ph.Ed. 585.

589. (Phsio. 589) Physiology of Pulmonary Respiration (2) Physiology of the lung including physical and chemical properties, synthesis of cellular constituents, gas exchange, and effects of unusual environments. Prerequisite: 3 credits of physiology at 400 or 500 level.

595. Philosophy of Health and Physical Education and Recreation (3) Prerequisite: Ph.Ed. 491 or Rc.Pk. 465.

PHYSICAL SCIENCE (PH SC)

John P. McKelvey
Chairman of the Committee on Physical Science
101 Osmond Laboratory

Degrees Conferred: D.Ed., M.Ed.

The M.Ed. program, designed to meet the needs of secondary school science teachers, requires at least 24 credits chosen from chemistry, physics, astronomy, mathematics, earth sciences, and biological sciences, including at least 9 each in chemistry and physics. In addition, a minor of at least 6 credits in education is required. The student must also complete a satisfactory term paper on a subject approved by the committee.

For admission to either the M.Ed. program or the D.Ed. program, the student is expected to have completed two years of college chemistry, one year of college physics at a level requiring calculus, mathematics through differential equations, and 18 credits in appropriate education and psychology courses.

Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

For the D.Ed. degree, the student is required to complete 24 credits in physical science, including chemistry, earth sciences, mathematics, and physics, which *may* (but are not required to be) in courses designed specifically for teachers. He is expected, beyond this, to complete 36 credits in standard 400- and 500-level courses, which *may not* be courses designed primarily for teachers; of these, 12 credits must be in chemistry, 12 in physics, and 12 in science and mathematics courses approved by the student's doctoral committee. In addition, 15 credits in education courses and 15 credits of thesis research are required. The student's selection of science courses should include at least 6 credits in experimental physics or chemistry.

A limited amount of work can be done during summer terms or off-campus, but a candidate must plan to be on the University Park Campus for at least four consecutive terms after he has been accepted as a D.Ed. candidate. The student will be required to take a candidacy examination after having completed about 30 credits of

graduate study, and a comprehensive examination after having completed his required course work. He must also present and defend a thesis, which may be either an experimental study in physics or chemistry, or an investigation of a problem in the teaching of physical science.

See also Earth Sciences, Chemistry, Mathematics, and Physics.

PHYSICS (PHYS)

DAVID H. RANK, *Head of the Department*
101 Osmond Laboratory

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors Bleuler, Cutler, Frankl, Gibbons, Henisch, Herman, Kazes, McCubbin, McKelvey, Müller, Polo, Pratt, Rank, Skudrzyk, Webb, and Wiggins; Associate Professors Atwater, Barsch, Eastman, Feuchtwang, Fleming, Freed, Kendall, Strother, Thwaites, Vedam, Weber, and Whitfield.

Graduate Faculty, Associate Members: Associate Professor Schumacher; Assistant Professors Graetzer, Lochstet, Madjid, McCammon, and Shaw.

Graduate instruction and research opportunities are available in visible and infrared spectroscopy, laser physics, solid state, field emission, thermionic emission, photoelectric emission, acoustics, low-temperature physics, nuclear physics, physics of high polymers, and of carotenoids, electron spin resonance of solids, and various phases of theoretical physics.

A bachelor's degree in physics or an allied field is required for admission to the M.S. and Ph.D. programs. Students who lack some of the usual upper-class undergraduate courses in physics may be requested to take additional course work without degree credit.

For admission to the M.Ed. program a student is required to have completed one year of general college physics plus two acceptable intermediate courses in physics, mathematics through integral calculus, and 18 credits in education and related psychology. The program requires at least 18 credits in physics, including approved laboratory work such as Phys. 560; at least 3 credits each in chemistry and mathematics; and at least 6 credits in education. The foreign language requirement specifies reading or introductory knowledge of two foreign languages, or comprehensive knowledge of one. With the approval of the head of the department the no-thesis option is available for the M.S. degree.

A grade point average of at least 2.50 in physics and mathematics courses taken during the junior and senior years of the applicant's undergraduate program will ordinarily be required for admission to the M.S., D.Ed. and Ph.D. programs. A grade point average of at least 2.50 in all courses taken during the junior and senior years of the applicant's undergraduate program will ordinarily be required for admission to the M.Ed. program. Exception to these requirements may be made for students with special backgrounds, abilities, and interests. Exceptions may also be made, at the discretion of the department, for applicants for doctoral programs who have satisfactorily completed master's degrees at other institutions.

PHYSICS (PHYS)

400. INTERMEDIATE ELECTRICITY AND MAGNETISM (4)
402. ELECTRONICS (4)
406. NUCLEAR PHYSICS (3)
410. INTRODUCTION TO QUANTUM MECHANICS (3)

412. Introduction to Solid State Physics (3)
419. (A.M. 419) Theoretical Mechanics (3)
420. Classical Thermodynamics (2)
421. Thermal Physics (2)
433. Mechanics and Fluid Physics for Teachers (3)
435. Electricity and Magnetism for Teachers (3)
436. Optics for Teachers (3)
437. Heat, Wave Motion, and Sound for Teachers (3)
439. Elementary Survey of Modern Physics for Teachers (3)
441. Demonstration Experiments for Teachers (3)
443. Intermediate Acoustics (3)
454. Atomic and Nuclear Physics (3)
456. Atomic and Molecular Physics (3)
457. Experimental Physics (1-2 per term)
458. Intermediate Optics (4)
461. (A.M. 461) Theoretical Mechanics (3)
467. Intermediate Electricity and Magnetism (3)
470. Special Topics (1-9)

509. Physics Seminar (1-3 per term) Topics from current research.

512-513. Introduction to the Quantum Theory of Solids (3 each) Energy band theory; electrical, optical, and magnetic properties; lattice dynamics; transport theory. Prerequisites: Phys. 412, 517.

517. Statistical Mechanics (3) Classical and quantum statistics; statistical thermodynamics; the Boltzmann transport equation; methods illustrated with applications to physical problems. Prerequisites: Phys. 420, 561.

518. Advanced Topics in Thermodynamics and Statistical Mechanics (3) Selected topics related to nonequilibrium thermodynamics, many-body problem, fluctuations, and statistical theory of random processes. Prerequisite: Phys. 517.

525. Methods of Theoretical Physics (3) Vector and tensor analysis; generalized coordinate systems; matrices and linear vector spaces of finite and infinite dimensionality; calculus of variations. Prerequisite: advanced calculus.

526. Methods of Theoretical Physics (3) Continuation of Phys. 525: complex variables; Hilbert space; Green's functions; orthogonal functions and boundary value problems. Prerequisite: Phys. 525.

530. Theoretical Mechanics (3) Newtonian mechanics; Lagrange's equations, Hamilton's principle; Hamilton's equations; coupled systems; waves in strings, central field problem; rigid bodies; elasticity; hydrodynamics.

532. Advanced Theoretical Mechanics (3) Least action principle; canonical transformation; Lagrange and Poisson brackets; Hamilton-Jacobi equations; classical theory of fields. Prerequisite: Phys. 530.

533. Theoretical Acoustics (3) Vibrating systems; transmission of disturbances through elastic and viscoelastic media. Prerequisite: Phys. 530.

550. (A.M. 550) Applied Group Theory (3) Representations of discrete and continuous groups, applications to theoretical physics and differential equations, varying emphasis on the specific applications. Prerequisite: A.M. 510.

553-554. Nuclear Physics (3 each) Discussion and theoretical interpretation of basic experiments involving atomic nuclei and nuclear radiations. Prerequisite: Phys. 562.

557. Electricity and Magnetism (3) Electro- and magnetostatics, Maxwell's equations, boundary value problems, electric and magnetic properties of material media.

558. Advanced Electricity and Magnetism (3) Energy and momentum in the field, radiation theory, classical relativistic electron theory. Prerequisite: Phys. 557.

560. Research Problems (1-10) Introduction to research through individual assignments.

561-562. Quantum Mechanics (3 each) The basic theory of wave and matrix mechanics, approximation methods, applications. Prerequisite: Phys. 530.

563-564. Advanced Quantum Mechanics (3 each) Relativistic wave equations, quantum field theory, other advanced quantum theoretical topics. Prerequisite: Phys. 562.

571. Atomic Physics (3) Experimental basis of modern physics; atomic spectra and structure, nuclear phenomena.

575. Special Topics (1-3 per term) Theoretical studies in any field of modern physics with or without associated experimental work. Prerequisite: Phys. 456.

PHYSIOLOGY (PHSIO)

Adam Anthony
Chairman of the Committee on Physiology
418 Life Sciences Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Almquist, Anthony, Barron, Baumgardt, Bortree, Buskirk, Buss, Flipse, Hale, Mendez, Morgan, Mueller, Pike, Schein, and H. Schraer; Associate Professors Amann, Hymer, Mortimore, Smyth, Strother, and Wickersham; Assistant Professors Dunson, McCarl, B. Pubols, and R. Schraer.

Graduate Faculty, Associate Members: Associate Professors Kollias and Nicholas; Assistant Professors Cornwell, Eberhart, Jefferson, Neely, Rhoades, Scholz, and Skinner.

This is an interdisciplinary program designed to enable students to obtain an integrated series of courses encompassing both the fundamentals of physiology and advanced training in a specialized area.

Graduate instruction in physiology is under the direction of a program committee composed of graduate faculty representing several departments or groups actively participating in the physiology program, including the areas of animal science, biochemistry, biophysics, and zoology, and the Human Performance Research Laboratory. The instructional staff is composed of the program committee as well as faculty in those departments offering graduate courses in various areas of specialization in physiology. The program, including courses, laboratory experience, and original research, is designed for completion in three to four academic years.

Students who present a 2.80 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

The entering student who lacks adequate preparation in chemistry, mathematics (through calculus), physics, or biological science must make up the deficiency early in his graduate program. All candidates (master's and doctoral) must complete a

general basic laboratory course in physiology (combined cellular, mammalian, and comparative) before choosing an area of specialization. Possible areas of specialization are cellular and subcellular physiology, environmental physiology, endocrinology, applied physiology (human performance), physiology of nutrition and metabolism, neurophysiology, or comparative physiology. The graduate committee for majors shall be appropriately represented by members of the physiology program committee and those of the area of specialization who shall have the responsibility and jurisdiction for determining the course program and research acceptable in satisfying degree requirements.

The following courses are available for physiology majors, and their descriptions may be found under the offerings of several departments: Anthy. 401; A.Ntr. 401, 402; Bioch. 401, 402, 417, 436, 437, 438, 501, 517, 519, 520, 521; Biol. 401, 470, 471, 475, 538, 539, 541, 575, 583; Bphys. 473, 474, 475, 580, 588; D.Sc. 427, 431, 512, 515, 521; Ent. 411; F.N. 452, 457, 459, 552, 557; Micrb. 401, 508; Psy. 402, 403, 503.

The following courses in physiology and biochemistry are offered at The Milton S. Hershey Medical Center: Anat. 505, 510, 535; Bchem. 502, 503, 513, 523, 540, 570, 590; Phsio. 520, 521, 525, 530, 550, 570, 590. Descriptions of these courses may be found on pages 259 to 265.

PHYSIOLOGY (PHSIO)

501. Seminar (1 per term)

510. Special Topics in Physiology (1-6)

571. (Biol. 571) Animal Physiology (2) Physiology and fluid transport mechanisms; examination of the distribution and regulation of body fluids, blood and hemodynamics. Prerequisite: 3 credits in physiology.

572. (Biol. 572) Animal Physiology (2) Examination of nutrition, metabolism, and respiration as they relate to subcellular, cellular, and organ organizational levels of the whole animal. Prerequisite: 3 credits in physiology.

573. (Biol. 573) Animal Physiology (2) Detailed examination of animal reproduction, endocrine secretion and control, neural muscular activity, central nervous system correlates, and special senses. Prerequisite: 3 credits in physiology.

574. (Biol. 574) Animal Physiology Laboratory (1-6) Selected problems using advanced physiological techniques to study transport mechanisms, circulation, excretion, respiration, metabolism, and neuroendocrines. Prerequisites: Phsio. 571, 572. Prerequisite or concurrent: Phsio. 573.

585. (Ph.Ed. 585) Applied Physiology (3) Presentation of current thinking on physiological mechanisms with emphasis on physically active man. Prerequisite: 3 credits in physiology at the 400 or 500 level.

586. (Ph.Ed. 586) Research Methods in Applied Physiology (3) Historical and current procedures for evaluation of cardio-pulmonary function, metabolism, and thermal balance in man; lecture, demonstration, and student laboratory. Prerequisite: 3 credits in physiology at the 400 or 500 level.

588. (Ph.Ed. 588) Special Topics in Applied Physiology (1-6) Critical discussion and evaluation of current research in applied physiology. Prerequisite: Phsio. 585.

589. (Ph.Ed. 589) Physiology of Pulmonary Respiration (2) Physiology of the lung including physical and chemical properties, synthesis of cellular constituents, gas exchange, and effects of unusual environments. Prerequisite: 3 credits of physiology at 400 or 500 level.

PLANT PATHOLOGY (PPATH)

JAMES TAMMEN, *Head of the Department*
211 Buckhout Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Bloom, Boyle, Kneebone, Lewis, Mills, P. E. Nelson, R. R. Nelson, and Tammen; Associate Professors Cole and Wood; Assistant Professor Merrill.

Graduate Faculty, Associate Members: Adjunct Professor Hyre; Associate Professor Schisler; Assistant Professors Lacasse, Lukezic, Stouffer, Wuest, and Adjunct Assistant Professor Leath.

Plant pathology is the study of disease in plants and concerns the dynamic interaction between the plant, the causal agent (bacteria, fungi, viruses, nematodes, etc.), and their environments. A student prepares for a professional career in research, teaching, extension, or industry through advanced studies of the principles of plant infection, the physiology of disease in plants, the ecology of root diseases, the nature and inheritance of disease resistance in plants, epidemiology, ecology and physiology of air pollution injury to plants, or plant disease control by biological or chemical means. A student also may specialize in the nature and control of the diseases of forest trees, agronomic or horticultural crops, and commercial mushrooms. Advanced studies in applied mycology, related to the production of the commercial mushroom, also may be taken. Modern, well-equipped laboratories, controlled environment facilities and greenhouses, and well-developed field research areas are available for graduate study.

For admission a student must present 42 credits in the natural sciences, including a minimum of 15 credits in the plant sciences and a minimum of 15 credits in mathematics, chemistry, or physics. Students with a strong background in agronomy, biochemistry, biophysics, botany, forestry, genetics, horticulture, or microbiology are usually well prepared for advanced study in plant pathology.

Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

PLANT PATHOLOGY (PPATH)

408.	PLANT PATHOLOGICAL TECHNIQUES (3)	*Mr. Bloom*
410.	INTERMEDIATE PLANT PATHOLOGY (1)	*Mr. Wuest*
411.	DISEASES OF ORNAMENTAL AND FLORICULTURAL PLANTS (2)	*Mr. P. E. Nelson*
412.	ADVANCED FOREST PATHOLOGY (2)	*Mr. Merrill*
413.	DISEASES OF FIELD CROPS (2)	*Mr. Leath*
414.	DISEASES OF FRUIT AND VEGETABLE CROPS (2)	*Mr. Boyle*
420.	PLANT PATHOGENIC BACTERIA (3)	*Mr. Lukezic*
422.	INTRODUCTION TO PLANT VIROLOGY (3)	*Mr. Boyle*
424.	ENVIRONMENTAL PATHOLOGY (3)	*Mr. Lacasse*
429.	PHYTONEMATOLOGY (3)	*Mr. Bloom*
430.	HISTORY OF PLANT PATHOLOGY (2)	*Mr. Merrill*

501. CLINICAL PLANT PATHOLOGY (3) Diagnosis and prognosis of disease; observe and evaluate the implementation of control practices. Prerequisite: P.Path. 408. *Mr. Wuest*

518. Special Problems (1-12) The prosecution of an assigned problem under the guidance of a staff member. Throughout the year as arranged. By appointment.

531. Plant Pathology Seminar (1 per term) Selected topics of current research, history, and contemporary trends in plant pathology. *Mr. Tammen*

540. Plant Disease Control (3) Principles of plant disease control, including theoretical considerations involved in control by chemical and nonchemical means. *Mr. Cole*

541. Physiology of Plant Disease (3) Physiology of the diseased plant, including the host response to the pathogen and parasitic properties of the pathogen. Prerequisite: Biol. 443. *Mr. Lukezic*

542. Epidemiology of Plant Diseases (4) Disease development in populations of plants, with emphasis on the impact of environment and control practices on rate of development. Prerequisite: 9 credits in plant pathology. *Mr. Wood*

543. Pathogen Variation and Host Resistance (3) Mechanisms and implications of genetic variation in plant pathogens related to breeding for disease resistance in plants by genetic means. *Mr. R. R. Nelson*

544. Pathological Plant Anatomy (2) Structural manifestations occurring in diseased plants. Prerequisites: Biol. 407, P.Path. 408. *Mr. P. E. Nelson*

560. Principles of Plant Pathology (3) Open-ended discussions of concepts of plant pathology, with emphasis on their interrelationships and their significance to the science. *Mr. R. R. Nelson*

POLITICAL SCIENCE (PL SC)

Robert S. Friedman, *Head of the Department*
129A Sparks Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty, Senior Members: Professors Albinski, Aspaturian, Atwater, Brown, Friedman, Hennessy, Mowitz, and Silva; Associate Professor Kochanek.

Graduate Faculty, Associate Members: Assistant Professors Keynes, LaPorte, Leduc, and Petras.

M.A. candidates will be comprehensively examined in American politics, comparative politics, international relations, political philosophy, or public administration. Candidates offering the thesis plan will also offer course work in one other of these substantive fields, or from among selected empirical theory-methodology courses. Candidates offering the non-thesis plan will offer course work in two of the above six fields. Ph.D. candidates will be comprehensively examined in three of the five substantive fields, in one subfield, and in a minor field or fields. Course work in empirical theory and scope and methodology is required. Competence must be demonstrated in approved skills selected from among foreign languages, statistics/mathematics, and computer science.

Admission requires the equivalent of at least 12 credits in political science. Students who present a 3.00 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions will be made for students with special backgrounds, abilities, and interests. Admission to the master's program will require two letters of recommendation and scores on the Graduate Record Examination (disci-

plinary, verbal, and quantitative ability). Admission to the Ph.D. program will entail evaluation of two letters of recommendation, scores on the Graduate Record Examination (disciplinary, verbal, and quantitative ability), and previous scholastic performance.

POLITICAL SCIENCE (PL SC)

401. Political Behavior (3) *Mr. Keynes*
403. The Legislative Process (3) *Mr. Keynes*
411. American Political Theory (3) *Messrs. Eisenach and Ricci*
412. International Organization: Economic and Social Functions (3) *Mr. Atwater*
413. Government and Politics of the Soviet Union (3) *Messrs. Aspaturian, Atwater, and Gilberg*
414. Foreign Policy of the Soviet Union (3) *Mr. Aspaturian*
415. International Organization: Political and Security Functions (3-6) *Miss Loomis; Messrs. Aspaturian, Atwater, and Brown*
416. International Law (3) *Miss Loomis*
417. American Local Government and Administration (3) *Messrs. Cook and Lee*
419. Bureaucracy and Public Policy (3) *Messrs. Lee and Monat*
425. Government and Politics of the American States (3) *Messrs. Friedman and Hennessy*
426. Political Parties (3) *Miss Silva*
427. Political Opinion (3) *Miss Silva and Mr. Hennessy*
431. Ancient and Medieval Political Theories (3) *Messrs. Eisenach and Ricci*
433. (L.M.R. 433) The Law of Labor-Management Relations (3)
441. Anglo-American Legal Systems (3) *Messrs. Eisenach and Keynes*
442. American Foreign Policy (3) *Messrs. Atwater and Brown*
444. Government and the Economy (3) *Mr. Hennessy*
445. Administrative Law (3) *Mr. Boyan*
447. Constitutional Law: The Federal System (3) *Miss Silva*
448. Constitutional Law: First Amendment Freedoms (3) *Mr. Boyan*
450. Canadian and Australian Politics and Foreign Policies (3) *Mr. Albinski*
451. Comparative Political Analysis (3) *Mr. Albinski*
452. Governments and Politics of Eastern Europe (3)
453. Political Processes in Underdeveloped Systems (3) *Messrs. Kochanek, LaPorte, and Petras*
454. Government and Politics of Africa (3) *Messrs. Brown and Kingsland*
455. Governments and Politics of Western Europe (3)
456. Politics and Institutions of Latin-American Nations (3) *Mr. Petras*
457. International Politics of Latin America (3-6) *Mr. Petras*
458. Governments and Foreign Policies of the Far East (3-6) *Mr. Kochanek*
459. Government, Politics, and International Relations of South Asia (3) *Mr. Kochanek*
460. Liberal and Democratic Political Theory (3) *Messrs. Eisenach and Ricci*
461. Authoritarian and Elitist Political Thought (3) *Messrs. Eisenach and Ricci*
462. Marxist and Socialist Political Theory (3) *Messrs. Eisenach and Ricci*
469. International Relations in South Asia (3-6)
473. Constitutional Law: Civil Rights (3)
499. Foreign Study in Government (2-6) *Miss Silva*

500. Political Power (3-6) Subject to be announced.

505. Executive Power (3-6) *Miss Silva and Mr. Monat*

509. Scope and Method of Political Science (3-6) *Mr. King*

512. Comparative Political Systems (3-9) *Messrs. Albinski, Kochanek, and Petras*

513. Seminar in Comparative Political Parties (3-6) Nature, function, organization, and leadership of parties; party systems, political culture, voting, and the institutional framework. *Mr. Albinski*

515. International Politics (3-6)

516. Seminar in International Relations Theory and Methodology (3) A detailed analysis of major traditional and contemporary theory-building efforts and contemporary research techniques and orientations in international relations.

517. International Organization (3-6) *Messrs. Aspaturian and Atwater*

518. Latin-American Politics (3-6) Forces which shape the quest for power and the process by which public policies are determined.

521. Modern Democratic Political Theory (3-6) *Mr. Ricci*

522. Comparative Foreign Policies (3-6) Major policies of selected nations which bear upon the search for international peace and security. *Mr. Aspaturian*

523. Soviet Political Behavior (3) Forces which shape rivalries for power; decision-making processes; areas of agreement and dissent. *Mr. Aspaturian*

524. Foreign Policies of the Soviet Bloc (3-6) Major policies, the decision-making process, and the impact upon component members and external rivals for power. *Mr. Aspaturian*

525. Comparative American State and Local Politics (3-6) Literature and research in comparative state and local political systems in the United States. *Mr. Friedman*

527. Politics and Legislative Behavior (3-6) Social factors which shape and determine the attitudes and decisions of American legislators and legislative bodies.

528. (Ed.Adm. 528) Politics and Education (3) Social forces which shape the educational system and determine national, state, and local educational policies.

529. Federal Systems (3-6) Features of the American federal system compared with those of other nations using the federal form. *Mr. Monat*

530. Public Law (3-6) The nature of law and its role in modern society. *Miss Silva*

531. Marxism and Political Socialist Theories (3) A systematic analysis and appraisal of major premises and deductions. *Messrs. Aspaturian and Ricci*

532. Empirical Political Theory (3-6) The impact of scientific method upon traditional political thought. *Mr. Keynes*

546. Judicial Process (3) Court functions in the political process; sources and limits of judicial power; perceptions of the judicial role; judicial decision-making. Prerequisite: 12 credits in political science.

554. African Political Systems (3-6) Impact of European colonialism; cultural and anthropological factors in political development; modernization and analysis of selected problems in contemporary Africa. Prerequisite: 3 credits of comparative government or international relations at the 400 level. *Mr. Brown*

571. Theory of Public Administration (3-6) The role of the executive in mod-

ern government; the objectives of public administration; theories of administrative organization and practice. *Mr. Mowitz*

572. International Development Administration (3-6) The execution of foreign policies through national and international public and private organizations. *Mr. LaPorte*

573. Comparative Public Administration (3-6) Administrative systems of selected nations on a functional basis; relationship between culture, economic and social systems, and public administration. *Mr. LaPorte*

574. Seminar in the Administration of United States Foreign Affairs (3) Effect of cross-cultural operations on the normal process of administration of United States foreign affairs. *Messrs. Brown and LaPorte*

575. Government Manpower Management (3) Government personnel systems; current trends and problems; essentials of recruitment, classification and pay, ratings, supervision, training, and discipline.

576. Government Fiscal Decision-Making (3) The role of the executive in fiscal planning; budget preparation; expenditure control; tax assessment and collection; investment of public funds. *Mr. Monat*

577. Organization and Systems Management (3) Principles of government organization; management surveys; work measurement; methods of achieving efficiency and economy. *Mr. Mowitz*

578. Urban Administrative Systems (3) Urban areas as administrative and policy systems; urban responses to problems of policy planning and implementation; approaches to urban analysis.

579. Methods of Analysis and Measurement in Public Administration (3) Examination and application of analytical techniques for evaluating organizational performance and program effectiveness in government agencies.

580. Internship in Public Administration (6)

584. Research Seminar in Public Administration (1-3) Application of research methods to problems of organization, management, and policy in public agencies; design and preparation of research project.

POULTRY SCIENCE (PTYSC)

Kenneth Goodwin, *Head of the Department*
105 Weaver Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Bressler, Buss, Goodwin, Hale, and Mueller; Associate Professors Hicks, Leach, and MacNeil.
Graduate Faculty, Associate Member: Assistant Professor Graves.

The department offers two types of graduate programs: (a) a program in poultry science, with one of the following major fields of interest: genetics, physiology, nutrition, behavior, food science, or poultry management; and (b) an interdepartmental program in one of the following disciplines: genetics, physiology, or food science.

In either case, the student's major program and his thesis research will be under the direction of a faculty member in the Department of Poultry Science.

Admission requirements include 30 credits in biology, chemistry, mathematics, and physics. Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

POULTRY SCIENCE (PTYSC)

401. (Biol. 401, Psy. 401) Animal Behavior (3) *Mr. Hale*
402. Special Topics (3-12)
405. Poultry Production Technology (3) *Mr. Mueller*

502. Advanced Poultry Nutrition (2-4) *Mr. Leach*

503. Advanced Poultry Farm Management (2-4) *Mr. Bressler*

504. Poultry Meat and Egg Technology (2-6) Prerequisites: Fd.Sc. 212 and 2 additional credits in poultry science. *Mr. MacNeil*

505. Research in Poultry Science (1-10 per term) Prerequisite: 9 credits in poultry science.

582. (Biol. 582, Psy. 582) Research in Animal Behavior (2-6 per term) Research in special areas of animal behavior involving field or laboratory work. *Messrs. Graves and Hale*

Note: *See Animal Science under "Other Elective Graduate Courses." Also see Food Science.*

PSYCHOLOGY (PSY)

Merrill E. Noble, *Head of the Department*
417 Psychology Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Carpenter, Cofer, Gorlow, Guthrie, Hale, Hall, Harris, Hoffman, Leibowitz, Lundy, Mitzel, Noble, Palermo, Taylor, Thevaos, Trumbo, and Warren; Associate Professors Draguns, Freeman, Schipper, Seibel, Sherif, Stern, and Urban; Mr. Greenhill.

Graduate Faculty, Associate Members: Associate Professors Dubin, Piers, and Whaley; Assistant Professors Berman, Cornwell, Galbraith, Martin, Ratliff, Sample, and Thomas.

Graduate instruction and research opportunities are available in the following areas of psychology: general experimental, physiological and comparative, animal learning, measurement and statistics, perception, social and personality, developmental, child, clinical, industrial and business, decision-making, engineering and human factors, verbal learning, and psycholinguistics.

Special research and training facilities include the Penn State Anechoic Chamber, the University Computation Center, the Animal Behavior Laboratory, the Psychology Clinic, the Division of Counseling, and the Special Education unit.

Requirements for admission include a broad undergraduate preparation, a junior-senior scholastic average of 3.00, a minimum of 12 credits in psychology, a satisfac-

tory graduate student rating on the Miller Analogies Test, and the Graduate Record Examination (General). Exceptions may be made for students with special backgrounds, abilities, and interests. Applicants with master's degrees will have their admission evaluated with emphasis on the quality of their graduate programs.

PSYCHOLOGY (PSY)

401. (Biol. 401, Phy.Sc. 401) Animal Behavior (3)
402. Sensation and Perception (3) *Mr. Freeman*
403. Introductory Physiological Psychology (3) *Mr. Cornwell*
404. Learning and Motivation (3)
405. The Experimental Psychology of Visual Perception (3) *Mr. Leibowitz*
406. Experimental Social Psychology (4)
408. Comparative Psychology (2-4)
409. Laboratory in Operant Conditioning (1-3)
410. History of Psychology (3) *Messrs. Freeman and Leibowitz*
412. Abnormal Psychology (3)
413. Biographical Psychology (3) *Mr. Harris*
415. Intermediate Experimental Design (3)
417. Social Psychology (3)
418. Measurement of Personality (3)
425. Child Psychology (3)
426. Adolescence (2-3)
430. Verbal Behavior and Verbal Learning (3) *Mr. Cofer*
431. Industrial Psychology (3)
432. Introductory Engineering Psychology (3)
433. Psychology of Occupational Behavior (2)
434. Information-Processing Laboratory (1-3)
436. Mental Health in Schools (3)
437. Psychology of Adjustment (3)
438. Theory of Personality (3) *Mr. Guthrie*
440. Psychology Projects (1-6)
441. Industrial Motivation and Morale (3)
445. (I.F.S. 445) Development Throughout Adulthood (3)
450. (Ed.Psy. 450) Principles of Measurement (3)
452. Laboratory in Sensory Processes (2-4)
453. Neuroanatomy Laboratory (1)
455. Physiological Psychology Laboratory (3)
474. Psychology of Exceptional Children (3)
482. Introduction to Clinical Psychology (3)

500. Seminar: Introduction to Graduate Study (2-6) Required of all new graduate majors in psychology.

503. Physiological Psychology (2-6) Correlations between structure and function of nervous system and human consciousness; laws and theories in fields of sensation, attention, association, affection, and thought. Prerequisite: 9 credits in psychology.

505. Research Problems in Psychology (1-15) Prerequisite: 12 credits in psychology.

509. Seminar in Conditioning and Learning (3-9) Prerequisite: Psy. 404 or Ed.Psy. 421.

511. Seminar in Contemporary American Psychology (2-3) Current systems or schools of psychology with comparative study and critical analysis; points of view as presented by recognized leaders. Prerequisite: 9 credits in psychology.

515. Advanced Statistics in Psychology and Education (3) Correlation theory

and methods, discriminant function, and factor analysis; applications to mental test theory. Prerequisite: Psy. 415 or Ed.Psy. 506.

516. Seminar in Quantitative Models (3-9)

518. Projects in Experimental Psychology (2-4) Individual experimental projects; seminars on experimental design and instrumentation.

527. Statistical Inference and Experimental Design (3) Probability theory, sampling distributions, analysis of variance and covariance, analysis of trend, nonparametric statistics, experimental design. Prerequisite: Psy. 415 or Ed.Psy. 506.

529. (C.D.F.R. 529) Seminar in Child Development (1-6) Readings and reports on recent findings in child development. Prerequisite: 6 graduate credits in child development, child psychology, or educational psychology, plus 3 in statistics. *Mr. Harris*

531. Seminar in Performance Theory (3-9) Topics in theory and research on human performance in perceptual-motor and information-processing tasks. Prerequisite: Psy. 432.

533. Seminar in Engineering Psychology (2-9) Design and operation of machines, man-machine allocation, the man-machine interface, displays, system-design, decision-making, image evaluation, and motor behavior. Prerequisite: Psy. 432.

535. Developmental Psychology (2-3) Developmental principles and concepts applied to psychological processes, with special reference to the experimental literature. Prerequisite: 9 credits in psychology.

536. (C.D.F.R. 536) Research Methods in Child Development (3) Prerequisites: 6 credits in child development and a course in statistics.

537. Seminar in Industrial Psychology (1-9) Prerequisite: Psy. 431.

538. Psychology of Personnel Development (3) Industrial training in relation to psychological learning theory and experimental findings. Prerequisite: Psy. 431 or Ed.Psy. 421.

539. Seminar in Motivation and Emotion (3-9) Systematic status of instinct, drive, motive, will, purpose; methodology and results of physiological, experimental, and clinical investigation of basic drives.

540. Seminar in Clinical Problems (1-6) Contemporary psychological theory, research, and methodology in relation to clinical psychology. Prerequisites: Psy. 542, 560.

541. Personality Theory (3-4) Contemporary theories of personality; relevant research. Prerequisite: Psy. 438.

542. Psychopathology (3-4) Theories of pathological behavior with reference to clinical and experimental data. Prerequisite: Psy. 412.

545. Seminar in Verbal Learning and Verbal Behavior (3)

549. (C.D.F.R. 549) Theories of Child Development (2-3) Historical background of the major theories concerning child development and behavior and their application. *Mr. Harris*

555. Theory and Practicum in Clinical Assessment (3-9) Theoretical issues and research in clinical assessment with special reference to administration and interpretation of testing procedures and clinical interviewing. Prerequisites: Psy. 541 or 542, and a course in measurement.

558. Clinical Child Psychology (3-9) Psychopathology of childhood; theories of etiology; diagnosis and treatment. Prerequisites: Psy. 555, 561.

559. (S.Psy. 559) The Individual Psychological Examination (3) Demonstrations and practice in widely used ability and aptitude tests; psychological report writing. Prerequisites: 15 credits in psychology and a course in measurement.

560. Practicum in Clinical Methods (1-6) Supervised practice in the Psychology Clinic, including assessment, therapy, report writing, and staff participation. Prerequisite: Psy. 555.

561. Clinical Practicum with Children (1-6) Diagnosis and counseling of child-parent problems of learning and adjustment. Prerequisites: Psy. 425, 426, 555.

569. Advanced Theory and Practicum in Counseling and Psychotherapy (3-9) Theoretical issues, research, and practicum experience in psychotherapy.

571. Seminar in Social Psychology (3-9) Historical development of theory and methods; determinants and principles of complex social or interactional behavior; contemporary problems and research.

580. Theory and Construction of Attitude Scales (3) Measurement of social, political, commercial, and industrial attitudes; questionnaire designs. Prerequisite: 3 credits in statistics.

581. Experimental Study of Primate Behavior (3) Taxonomy of contemporary species of primates; ontogeny of learning, perception, and affective behavior; interspecies comparisons of behavior.

582. (Biol. 582, Pty.Sc. 582) Research in Animal Behavior (2-6 per term) Research in special areas of animal behavior involving field or laboratory work.

590. Problems in Clinical Research (1-6) Prerequisite: Psy. 415.

591. Seminar on Teaching Psychology (1-3) Objectives and content of psychology; organization and presentation of material; teaching aids and techniques.

PUBLIC ADMINISTRATION (PUB A)

Robert J. Mowitz
Director of the Institute of Public Administration
302 Engineering E

Degree Conferred: M.P.A.

Graduate Faculty, Senior Members: Professors Friedman and Mowitz.
Graduate Faculty, Associate Members: Associate Professor Riew; Assistant Professors LaPorte, Leduc, Petras, and Westby.

All candidates take a core program and may concentrate through electives in one of the following areas: general public administration, public planning administration, comparative and international administration, urban administration, human resources administration, and natural resources administration.

Candidates for admission ordinarily will have at least 12 hours of undergraduate credit in the social sciences. Candidates for the degree may be required to take some courses without graduate credit in order to complete a major designed for their professional needs.

Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for the students with special backgrounds, abilities, and interests.

RECREATION AND PARKS (RC PK)

Betty van der Smissen
In Charge of Graduate Programs in Recreation and Parks
260 Recreation Building

Degrees Conferred: M.S., M.Ed.

Graduate Faculty, Senior Members: Professors Coombs, Gross, and van der Smissen; Associate Professor Nelson.

The graduate program is designed to prepare students for administrative, supervisory, research, and teaching positions in public recreation and park systems, in colleges and universities, in voluntary agencies, and in institutions.

The program is oriented to meet the specific needs and research interests of the candidate. Areas of specialization include (1) recreation and park administration, including outdoor recreation planning, (2) recreation program supervision and administration, including recreation for special groups, (3) camping, outdoor education, and outdoor interpretive services, and (4) professional education.

The master's degree may be earned in the major field of recreation and parks. At the doctoral level, the Ph.D. and D.Ed. may be earned with a specialization in recreation and parks within the physical education major. Write for details.

For admission to the graduate program, a bachelor's or master's degree is required in recreation, park administration, or in a related field, e.g., forestry, landscape architecture, sociology, psychology, physical education, education, or fine arts. Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

RECREATION AND PARKS (RC PK)

420. Outdoor Recreation (3)
425. Interpretive Services (3)
430. Outdoor Education (3)
440. Camp Administration (3)
456. Recreation Program Organization (3)
458. Dynamics of Recreation Groups (3)
461. Community Recreation (3)
465. Administration of Recreation and Parks (3)
470. Metropolitan Park Management (3)
475. Therapeutic Recreation in the Community (3)
477. Therapeutic Recreation in the Rehabilitation Setting (3)
498. Special Projects (1-6)

500. (Ph.Ed. 500) Individual Study and Research Projects (1-10) Prerequisite: Rc.Pk. 530.

515. Program Development and Supervision (3) Critical analysis of the indi-

vidual, political, and societal determinants of recreation programming; demonstration projects; evaluative procedures, research functions in programming. Prerequisite: Rc.Pk. 456.

520. Seminar in Camp Administration (3) Values inherent in the camp experience; critical analysis of philosophical choices and sponsor objectives as influencing program development. Prerequisite: Rc.Pk. 230 or 430.

530. (Ph.Ed. 530) Research Techniques in Health and Physical Education and Recreation (3)

533. Recreation Studies, Surveys, and Appraisals (3) Advanced research procedures related to special recreation and park problems. Prerequisites: Rc.Pk. 530 and 3 credits in statistics.

540. Public Recreation Lands (3) Planning recreation lands; legislation, financing, intergovernmental coordination to acquire and develop open space land, urban recreation and park master plan.

550. Seminar in Recreation and Parks (1-6)

560. Administrative Problems of Recreation and Parks (3) Special problems of recreation and park departments; legal powers and liability; departmental organization, financing, personnel policies, and staff development. Prerequisite: Rc.Pk. 465.

590. Philosophical and Social Bases of Recreation (3) Philosophical and social bases of recreation; analysis of critical issues of recreation for philosophical and social implications.

REGIONAL PLANNING (R PL)

Frank B. Burggraf, Jr.
Chairman of the Committee on Regional Planning
318 Sackett Building

James I. Clark
Program Head for Regional Planning
at the Capitol Campus

Degree Conferred: M.R.P.

The objective of this program is to train competent professional planners aware of the needs of citizens and the programs for sound social, political, economic, and cultural advancement through the enlightened management of all resources. For admission a student should have had at least one course each in sociology or political science; physical geography, geology, or soils; and graphics or cartography, plus college level mathematics or statistics. The program is offered at University Park and at the Capitol Campus in Middletown.

Students who present a 3.00 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

REGIONAL PLANNING (R PL)

400-401. Principles of Regional Planning (3 each)

REGIONAL PLANNING

410. Planning Programs (3)
420. Theory and Methodology of Regional Planning (3)
440. Problems in Community and Regional Planning (1-9)

510. Planning Techniques and Analysis I (3) Regional socioeconomic structure, problems, and factors in planning; data collection, analysis, and implications.

520. Planning Techniques and Analysis II (3) Interaction of man and environment; land and water resources in regional planning; environmental factors as planning parameters.

530. Planning Techniques and Analysis III (3) Physical, aesthetic, and cultural design aspects of planning. Cultural value judgments and environmental design.

540. Problems in Regional Planning (1-9) Planned individual projects involving library, laboratory (studio), or field work.

600. Thesis.

610. Thesis.

RURAL SOCIOLOGY (R SOC)

Lee M. Day
Head of the Department of Agricultural Economics and Rural Sociology
6-A Weaver Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty, Senior Members: Professors Bealer, Brown, John, and Smith.
Graduate Faculty, Associate Member: Assistant Professor Willits.

In all programs emphasis is on a comprehensive understanding of the various facets of societal organization pertinent to the rural sector. While scope is encouraged, there are available certain areas of special interest and research: consumer behavior; instigated social change; community structure; human resource development; migration; adolescent behavior; the culture of poverty; the ecology of rurality in industrialized, urbanized society. All students are required to have training in sociological theory, statistics, and research methods.

The entering student in the master's program should have as prerequisites 3 credits in rural sociology, 3 credits in sociology, and 3 additional credits in either field. If he does not have these prerequisites, he may take them at the University during the early part of his master's program.

Students who present a 2.75 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

RURAL SOCIOLOGY (R SOC)

401. Special Topics in Rural Sociology (1-6)
402. Consumer Behavior and the Agricultural Industry (3)
444. Rural Life in an Industrial Society (3)
452. Rural Organization (3)
459. Rural Social Psychology (3)

501. Development of Rural Sociology (2) Historical development with emphasis on American rural sociology.

502. Advanced Rural Sociology (3) Structure and functioning of rural society; evaluation of theoretical systems.

510. Rural Migration (2) Rural migration research and theory; application to governmental and community problems.

512. National Farm Organizations (2) National farm organizations as social systems. Prerequisite: R.Soc. 452.

513. Sociology of Consumer Behavior (2) Sociological theory and research pertaining to consumer behavior.

514. Values in Rural Society (2) Values as dynamic forces in rural society.

515. Extension Organization and Methods (2) Agricultural and home economics extension as a social system, with emphasis on techniques of organization and program development.

516. Change in Rural Society (2) Social change in rural society, emphasizing prediction and control of the change process.

551. Rural Sociology Seminar (1-6) Prerequisite: 6 credits in rural sociology, sociology, or psychology.

SANITARY ENGINEERING (S E)

Benjamin A. Whisler
Head of the Department of Civil Engineering
212 Sackett Building

Degrees Conferred: M.S., M.Eng.

Graduate Faculty, Senior Members: Professors Kountz, Nesbitt, and Whisler.
Graduate Faculty, Associate Members: Associate Professor McDonnell, Assistant Professor Unz.

The entering student should be a graduate in engineering from an accredited college of engineering. A student wishing to obtain a Ph.D. degree may major in civil engineering with emphasis on sanitary engineering.

Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

The following courses offered by the Department of Civil Engineering are appropriate for students majoring in sanitary engineering (course descriptions are given under Civil Engineering): C.E. 451, 452, 462, 465, 471, 472, 551, 564, 571, 572, 573, 574, 575, 576, 577, and 580. Appropriate courses offered by other departments include: Ag. 400; Ag.Ec. 422, 505; Bioch. 401, 402, 425, 436; Biol. 410; Chem. 405; Cmp.Sc. 402; Geol. 452; I.E. 405, 509, 510; M.E. 401, 405, 506, 521; Meteo. 473, 502; Micrb. 401, 417; Nuc.E. 420; Pl.Sc. 419, 578; P.Path. 424; R.Pl. 400, 401, 410, 510, 520.

SCHOOL PSYCHOLOGY (S PSY)

Joseph L. French
Chairman of the Committee on School Psychology
101 Education Building

Degrees Conferred: D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors French, Noble, and Rabinowitz; Associate Professors Sabatino and Smith.

Graduate Faculty, Associate Members: Associate Professor Snyder, Assistant Professor Ratliff.

This interdisciplinary program based on courses in psychology, educational psychology, special education, and related fields is designed to produce dually oriented professionals who are well prepared in both psychology and education. The objective is to develop a psychologist who is interested in and knowledgeable about schools. The school psychologist must utilize his professional skills and his knowledge about children and youth to make contributions which are meaningful to and utilized by teachers. The development of competencies needed by a fully qualified school psychologist requires at least the education represented by a doctoral degree. Other areas of study related to school psychology, such as clinical psychology, general educational psychology, counselor education, and child development, are found in other departments of the University.

Practicum facilities include the speech pathology and audiology out-patient service, the Reading Center, the Psychology Clinic, and the Demonstration School for mentally retarded children. Facilities for work with children are available through other departments also.

An undergraduate major in psychology or in education of exceptional children is expected of applicants, but students with fewer than 15 credits in psychology may be admitted with limited deficiencies to be made up concurrently with their graduate studies. Requirements for admission include a minimum junior-senior scholastic average of B and a satisfactory scholastic aptitude rating. Applicants with a master's degree will be required to show more than a minimum success in graduate study, including at least one-third of their graduate credits of "A" quality.

Applicants who are able to present at least a 2.85 average in their junior and senior years (or a master's degree with one-third or more grades of *A* quality); satisfactory recommendations; and scores of 500 or higher on the general sections of the Graduate Record Examination, or a raw score of 58 or higher on the Miller Analogies Test, or a raw score of 35 or higher on the Quantitative Evaluative Device is the group from which new students are selected, within the limitations of departmental facilities. Exceptions to these requirements may be made for students with special backgrounds, abilities, and interests.

SCHOOL PSYCHOLOGY (S PSY)

500. Professional Issues in School Psychology (1-3) Orientation to the field through study of unique problems, current issues, ethical and legal matters, unique cases, and research projects.

504. Practicum in School Psychology (1-6) Clinical experience with children under supervision in a variety of settings requiring service including practice in synthesizing data and observations.

508. Internship in School Psychology (1-10) Long term placement in settings providing work for school psychologists with children, parents, teachers, administrators, and service agencies under supervision.

559. (Psy. 559) The Individual Psychological Examination (3) Demonstrations and practice in widely used ability and aptitude tests; psychological report writing. Prerequisites: 15 credits in psychology and a course in measurement.

SECONDARY EDUCATION (SECED)

Gerald R. Bosch
In Charge of Graduate Programs in Secondary Education
148 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors Fagan, Fowler, Remaley, and Withall; Associate Professors Heimer and Pendered.

Graduate Faculty, Associate Members: Associate Professors Koble, Kozak, Searles, and Shemick; Assistant Professors Dupuis and Ribble.

Graduate degree programs emphasize the advanced preparation of classroom teachers, special supervisory personnel, and curriculum specialists. Candidates for the D.Ed. and Ph.D. degrees with a major in secondary education must meet all the requirements, including residence, described in the earlier sections of this bulletin. For admission to the D.Ed. program at least 18 credits in education and related psychology are required.

Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests. Also required is a provisional certificate to teach in secondary schools, two letters of recommendation, and scores on the Graduate Record Examination (aptitude and advanced sections).

Candidates for the D.Ed. degree with a minor in secondary education must take a minimum of 15 course credits approved in advance by the person in charge of the major in Secondary Education. When course work has been completed more than five years prior to admission to the D.Ed. or when it is transferred from another institution, the chairman of the graduate faculty will determine its suitability for any part or all of the 15 hours required.

Candidates for the M.S. degree with a major in secondary education will fulfill all the requirements for that degree, including a thesis, which are listed previously in this bulletin. Candidates with a minor in secondary education must have 6 credits in education approved by the chairman of the graduate faculty. In general, candidates for the M.Ed. in secondary education must have 18 approved undergraduate credits in education and psychology including practice teaching in an area appropriate to the major, and aptitude for and interest in advanced professional preparation. Applicants are urged to have had at least two years of successful teaching experience before completion of the degree requirements. Although candidates are required to specialize in secondary education, they are encouraged to increase their general education in the social sciences, the behavioral sciences, and the humanistic foundations.

The M.Ed. degree may be earned in those fields outside of secondary education for which a master's degree has been approved, provided such a professional program is appropriate. For example, the M.Ed. degree may be earned with a major in English or geography. These programs require 6 credits in professional education approved in advance by the head of the department or the person responsible for the minor field chosen, e.g., secondary education, agricultural education, etc.

Graduate Record Examination scores on both aptitude and education sections are required of all candidates.

SECONDARY EDUCATION (SECED)

400. Introduction to Research Literature (3)
426. Teaching Mathematics in the Secondary Schools (4)
433. Teaching Social Studies in the Secondary Schools (4)
436. Teaching of Conservation of Natural Resources in the Secondary School (3)
438. Teaching Science in the Secondary Schools (4)
443. Reading Problems in the Secondary School (2-3)
445. (E.E.C. 445, El.Ed. 445) Techniques in Remedial Reading (2-6)
451. Secondary Education in America (3)
453. Teaching English in the Secondary Schools (4)
454. Extracurricular Activities in the Junior and Senior High School (2-3)
472. Measurement of Achievement in the Secondary School (2-3)
490. (Human. 490) The Teaching of the Humanities (3)
497. Workshop in Selected Studies in Secondary Education (1-6)

510. Internship in Secondary School Teaching (3-6) Internship to take place in schools or educational situations where student is not regularly employed, under supervision of graduate faculty.

526. Research Problems in the Teaching of Mathematics (3) Research techniques and procedures dealing with the study of curriculum, materials, evaluation, teaching, learning, and supervision of mathematics. Prerequisites: Sec.Ed. 426, Ed.Psy. 406, and teaching experience.

532. Supervision of Student Teachers (3) A course in supervision for master teachers, department heads, and college teachers with supervisory responsibilities in teacher education. Prerequisites: teaching experience and 18 credits in education including at least 5 in methods.

533. Research Problems in the Teaching of Social Studies (3) Historical-philosophical bases for the social studies: curriculum development, research findings and techniques, learning resources and promising proposals. Prerequisites: Sec.Ed. 433 and teaching experience.

537. (Biol. 537) Workshop in the Biological Sciences (3) Projects designed for teachers of biology in the secondary schools.

538. Research Problems in Science Teaching (3) Problems and research dealing with curriculum, materials, evaluation, and supervision of science teaching and learning. Prerequisites: Sec. Ed. 438 and teaching experience.

539. Research Problems in the Teaching of English (3) Cooperative study by specialists, teachers, and administrators of problems and research findings in the teaching of English in American schools. Prerequisites: Sec.Ed. 453 and teaching experience.

546. (El.Ed. 546) Seminar on Reading Instruction (3-6) Research procedures and materials in reading readiness, word perception, basic reading skills, vocabulary deveolpment, reading in content subjects. Prerequisite: Sec.Ed. 443 or El.Ed. 443.

550. Problems in Modern Secondary Education (3) Historical, psychological, social, and economic factors influencing secondary education. Prerequisite: secondary school teaching.

551. Seminar in Contemporary Issues in the Secondary School Curriculum (2-3) Principles and philosophy of curriculum construction. Each student works out an individual problem in the secondary school curriculum. Prerequisites: 12 credits in education and psychology, and teaching experience.

553. Organization and Administration of the Junior High School (2-3) Problems in reorganization of secondary education, with particular reference to philosophy, organization, and teaching problems of the junior high school. Prerequisites: 12 credits in education and psychology, and teaching experience.

585. Curriculum Construction (2-3) Functions of administrators, supervisors, teachers, pupils, and laymen in curriculum building to meet pupil and community needs.

594. Seminar in Secondary Education (1-3) Conferences and discussions designed to meet the need for special study of particular fields in secondary education. Prerequisite: 12 credits of graduate work in education.

598. Problems, Projects, and Area Studies in Secondary Education (1-6) Independent work in the study of topics in secondary education or the development of new curriculums, materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of the department head.

SLAVIC LANGUAGES AND LITERATURES (S L L)

William R. Schmalstieg
Acting Head of the Department of Slavic Languages
440 Burrowes Building

Degree Conferred: M.A.

Graduate Faculty, Senior Members: Professors Magner and Schmalstieg, Associate Professor Birkenmayer.

Graduate Faculty, Associate Member: Associate Professor Paternost.

Opportunities for specialization in literature or linguistics are available. A minimum requirement for admission is an undergraduate major in Russian or its equivalent.

Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

The department prefers that M.A. candidates in this major submit a term paper rather than a thesis.

RUSSIAN (RUS)

426. Dostoevsky (3)
427. Tolstoy (3)
430. Methods and Materials for Teaching Russian (3)
450. History of the Russian Language (3)
460. Linguistic Analysis of Contemporary Russian (3)
497. Problems in Russian (3-9)

*1G. Technical Russian for Graduate Students (3) Prepares student to translate technical and scientific texts. No previous knowledge of Russian is required.

*2G. Russian Texts (3) Development of skill in translating Russian texts in the sciences and social sciences. Prerequisite: Rus. 5 or 1G.

* No graduate credit is given for this course.

501. Readings in Russian Literature (3-6) Prerequisite: Rus. 204.

525. Pushkin (3) Pushkin's significance in Russian literature; his relation to other European literatures; *Eugene Onegin* and selected shorter works.

540. Seminar in Old Russian Literature (3) Literary and linguistic analysis of Russian literary monuments in the original, 1100-1800. Prerequisite: Rus. 450.

542. Seminar in Soviet Literature (3-6) Works of representative Soviet writers; individual research in contemporary Soviet literature and literary criticism.

570. Seminar in the Analysis of Old Russian Literary Documents (3-6) Reading, translation, interpretation, and analysis of old Russian literary documents. Texts differ from those read in Rus. 540. Prerequisite: Slav. 550.

SLAVIC (SLAV)

500. Bibliography and Research Techniques (3) Tools and methods of research, designed for students preparing to do independent investigation of problems in Slavic languages and literature.

510. Structure of the South Slavic Languages (3-12; 3 credits per language) Linguistic analysis of a particular South Slavic language (Bulgarian, Macedonian, Serbo-Croatian, Slovenian). Comparative study of all the South Slavic languages. Prerequisite: Rus. 460 or one graduate course in linguistics.

550. Old Church Slavic (3) Reading and study of that corpus of religious and liturgical documents representing the first written records of a Slavic tongue.

560. Theory and Technique in Slavic Linguistics (3-6) Analysis of the relationship of the Slavic languages; consideration of particular linguistic problems within one or more of the lanugages.

SOCIAL STUDIES (SO ST)

Hugo A. Meier
Chairman of the Committee on Social Studies
214 Sparks Building

Degree Conferred: M.Ed.

This program, designed to meet the needs of secondary school teachers, requires at least 24 credits chosen from economics, history, human geography, political science, and sociology. A candidate is expected to complete at least 3 credits each in four of these areas but not more than 12 in any one of them. A minor of at least 6 credits in educational foundations is also required.

For admission a student must have had solid preparation in the basic courses in economics, history, political science, and sociology and should have had some advanced undergraduate work in at least one of these areas. He must also have had 18 credits in education and related psychology, and he should be certified for teaching social studies. Ideally, he should have had teaching experience in this field as well.

Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

SOCIOLOGY (SOC)

DONALD P. KENT, *Head of the Department*
237 Temporary Office Building

Degrees Conferred: Ph.D., M.A., M.Ed.

Graduate Faculty, Senior Members: Professors Buck, Clark, Kent, Matson, Sherif, and Theodorson; Associate Professors Aurbach and DeJong.

Graduate Faculty, Associate Members: Professor Foreman; Associate Professors Faulkner, Raphael, and Sim; Assistant Professor Westby.

Major research and instructional areas of emphasis include sociological theory, research methods and statistics, social psychology, demography and ecology, community structure, industrial and occupational sociology, gerontology, and the sociological analysis of institutions, including political, religious, and educational sociology. A thesis is required of all M.A. candidates in this major.

Undergraduate preparation must include 12 credits in sociology and at least 6 in other social sciences. Students of exceptional ability who are deficient in undergraduate preparation may be accepted provided they make up their course deficiency without graduate credit. Students presenting a 3.00 junior-senior average and scores on the Graduate Record Examination (general and special fields) is the group from which new students are selected, within the limitations of departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

SOCIOLOGY (SOC)

400. ADVANCED GENERAL SOCIOLOGY (3)
401. SOCIAL INSTITUTIONS (3)
403. ADVANCED SOCIAL PSYCHOLOGY (3)
404. SMALL GROUPS (3)
406. SOCIOLOGICAL ANALYSIS OF DEVIANCE (3)
408. SOCIAL ECOLOGY (3)
412. PENOLOGY (3)
413. METHODS AND TECHNIQUES OF SOCIAL RESEARCH (3)
415. THE URBAN COMMUNITY (3)
416. (C.F.Ed. 416) SOCIOLOGY OF EDUCATION (3)
418. THE DEVELOPMENT OF SOCIAL THOUGHT (3)
419. NEGRO-WHITE RELATIONS (3)
422. HISTORY OF SOCIOLOGICAL THEORY (3)
423. POPULATION ANALYSIS (3)
424. SOCIAL CHANGE (3)
426. PUBLIC WELFARE POLICY AND SERVICES (3)
427. SOCIAL CASE WORK (3)
428. SEMINAR IN SOCIOLOGY (1-6)
429. SOCIAL STRATIFICATION (3)
430. FAMILY IN CROSS-CULTURAL PERSPECTIVE (3)
432. COLLECTIVE BEHAVIOR (3)
435. SOCIAL GERONTOLOGY (3)
436. (Journ. 436) SOCIOLOGY OF OPINION FORMATION (3)
438. (Rl.St. 438) RELIGION AND URBAN SOCIETY (3)
444. COMPLEX ORGANIZATIONS (3)
446. POLITICAL SOCIOLOGY (3)
450. COMMUNITY ORGANIZATION (3)
453. (Anthy. 453) PRIMITIVE RELIGION (3)
454. (L.M.R. 454) INDUSTRY AND THE COMMUNITY (3)

455. (L.M.R. 455) Occupations and Professions (3)
456. Readings in Sociology (1-9)
457. (L.M.R. 457) Field Work in Industrial Sociology (1-6)
461. (Rl.St. 461) Sociology of Religion (3)
470. Intermediate Social Statistics (4)
473. Methods of Demographic Analysis (3-6)
499. Foreign Study in Sociology (2-6)

500. Seminar in Group Theory (1-3) The group as a unit of social structure and action.

502. Theories of Society (3) Past and present theories of the over-all structure and processes of societal functioning.

503. Research Seminar in Social Psychology (3-6) Design and conduct of research in areas of mutual interest in social psychology.

504-505. Current Social Theory (3 each) Current contributions to social theory; their relations to each other and to the larger theoretical structure.

506. Seminar in Sociological Theory (3-9)

507. Introduction to Graduate Study in Sociology (1) Required of all incoming graduate students in sociology.

510. Field Work in Sociology (1-6)

512. Seminar in Deviant Behavior (2-6) Advanced sociological study of crime, juvenile delinquency, mental disorders, suicide, drug addiction, prostitution, and other social deviation. Prerequisite: 6 credits in sociology.

513-514. Sociological Methods (3 each) Critical review of methodological issues; philosophy of science; research designs; analysis and interpretation of findings. Prerequisites: Soc. 413, 470.

515. Seminar in Community Studies (3)

518. Research Studies in the Sociology of Education (3) Analyses of the design, methods, and findings of selected classical and current research studies in the sociology of education. Prerequisite: Soc. 416.

523. Seminar in Population Theory (1-6) Critical review of population theory and research with emphasis on the sociological aspects of demographic behavior. Prerequisite: 3 credits in population or human ecology.

525. Seminar in Sociology (1-6) Research problems in theoretical and applied sociology.

529. Seminar in Intergroup Relations (3) Review of research into minority-majority group relations.

530. Research on Marriage and the Family (3) Training in methods and techniques of research in family relations. Experimental, statistical, and comparative studies are carried out, individually or cooperatively. Prerequisite: 3 credits of previous work in this field.

532-533-534. Social Relations (3 each) Critical appraisal of major social-psychological problems confronting modern man; emphasis on formulation of fruitful research projects and their evaluation. Prerequisite: 15 graduate credits in social science departments or psychology, including a course in statistics.

535. Seminar in Gerontology (2-6) A structural-functional analysis of current

research dealing with the relationships between institutional structure, age grading, and social behavior.

*546. Seminar in Political Sociology (3-6) Research and analysis of contemporary issues in political sociology. Prerequisite: 3 credits in statistics.

555. Industrial Sociology (3) Research methods and techniques in industrial sociology; current research, unexplored areas.

572-573. Social Statistics (3 each) Application of parametric and non-parametric statistical methods to sociology; sampling; computer data processing techniques. Prerequisites: Soc. 470 and 3 credits in research methods.

574-575. Quantitative Sociology (3 each) Problems and issues in the mathematical and quantitative aspects of sociology. Prerequisites: Soc. 413, 470.

SOLID STATE SCIENCE (S S S)

Laxman N. Mulay
In Charge of Graduate Programs in Solid State Science
101 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Brindley, Cross, Henisch, Kline, Muan, Mulay, Roy, and Walker; Associate Professors Barch, Dachille, Inman, Newnham, Vastola, Vedam, Weber, and W. White; Mrs. Roy; Assistant Professors Knox and E. White.

Graduate Faculty, Associate Members: Assistant Professors Johnson and McKinstry.

This program is one of the options in which a graduate student in the Department of Materials Science can receive an advanced degree. The aim of this program is to provide an opportunity for the student interested in the structure, properties, and behavior of solid materials to obtain an integrated program of courses encompassing both the necessary fundamentals of chemistry, physics, and mathematics and their technological and engineering applications.

The program of courses taken by a student majoring in this field must necessarily cut across two or more disciplines. The relevant subject matter has been grouped into four areas: (1) the structure of solids (crystal chemistry and structure determination); (2) theory related to the solid state (physics, chemistry, and mechanics); (3) properties of solids (optical, electrical, magnetic, mechanical, thermal, and chemical); and (4) reactions of solids (phase equilibria, reaction mechanisms, reaction kinetics, and surface reactions).

The course work of all students will normally include the "core program" as periodically redefined by the committee. Recommended course sequences for each year for students with different undergraduate backgrounds are prepared by the chairman and are available from the student's adviser.

Entering students should hold a bachelor's degree in chemistry, physics, mathematics, geological science, engineering, ceramics, or metallurgy, or in a closely related field that will have included in it mathematics at least through integral calculus and a minimum of one year of physics and one year of chemistry. Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental

* 3 credits per term.

facilities. Exceptions may be made for students with special backgrounds, abilities, and interests. The applicant should be interested specifically in an interdisciplinary program of study and research. Dissertation research on various aspects of the solid state may be conducted in the Materials Science Department and other appropriate departments in the Colleges of Earth and Mineral Sciences, Engineering, and Science; in the Materials Research Laboratory; and in the Ordnance Research Laboratory. The experimental facilities for research in several aspects of materials science and engineering are exceptional.

S.S.S. 500 (seminar) and S.S.S. 590 (special research problems) will be offered to promote the interdisciplinary aspects of solid state science. Further information will be available from the S.S.S. office.

In addition to the departmental courses, students may select appropriate course work from any engineering or science department. The following list includes those which are most commonly taken to satisfy the requirements; descriptions may be found under the appropriate department headings. Structure of Solids: Chem. 516; Gchem. 512; Min. 463, 500; Mn.Sc. 421, 510, 513. Solid State Theory: Chem. 544, 545, 565, 566, 567; E.Mch. 507, 516, 531, 540; Metal. 514; Phys. 410, 412, 470, 512-513, 517, 561-562, 571. Physical Properties of Solids: Cer.Sc. 506, 507, 508; Chem. 455; E.Mch. 414, 506, 530, 533, 546; Metal. 516; Nuc.E. 509. Chemical Reactions in Solids: Cer.Sc. 503, 504, 511, 512; Chem. 563; F.Sc. 506, 515; Gchem. 513, 520; Metal. 508, 515, 518, 522.

SOLID STATE SCIENCE (S S S)

500. Seminar in Solid State Science (1 per term) Topics from current research depicting various aspects of the solid state.

590. Research Problems in Solid State Science (1-4) Specialized theoretical and/or experimental techniques related to research topics in solid state science.

SPANISH (SPAN)

Martin S. Stabb
Head of the Department of Spanish, Italian, and Portuguese
352 Burrowes Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty, Senior Members: Professors Moser, Pérez, and Sturcken; Associate Professor Brentin; Assistant Professor Lima.

Graduate Faculty, Associate Members: Associate Professors Dalbor and Triolo; Assistant Professors Halsey, Lyday, and Solera.

The minimum requirement for admission will normally be 24 credits of post-intermediate work in Spanish language and literature. A student may specialize in either the area of literature or descriptive and historical linguistics. The department may waive the requirement of a thesis for M.A. candidates in this major.

Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

SPANISH (SPAN)

400. Advanced Composition and Conversation (3)

404. The Evolution of Spanish (3)
413. The Teaching of Spanish (4)
414. Spanish Phonology (3)
416. Old Spanish Literature (3)
426. The Golden Age (3)
427. Drama of the Golden Age (3)
439. Don Quijote (3)
452. Spanish Literature in the Romantic Period (3)
459. The Generation of 1898 (3)
472. The Contemporary Spanish-American Novel (3)
475. Introduction to Latin-American Literature (3)
476. Introduction to Latin-American Literature (3)
477. The Literature of Mexico (3)
480. Literature of the Gaucho (3)
482. Spanish Lyric Poetry (3)
483. Spanish Drama of the 19th Century (3)
487. The Spanish Novel of the 19th Century (3)
498. Problems in Hispanic Literature (3-12)
499. Foreign Study in Spanish (3)

502. Theory and Techniques of Teaching Spanish (1-3) Audio-lingual orientation.

503. Methods and Bibliography in Spanish (1-3) Methods of research; evaluation of sources and materials.

505. Old Spanish: Phonology, Morphology, and Syntax (3)

506. History of the Spanish Language (3)

507. Hispano-Romance Linguistics (3)

510. Spanish Descriptive Linguistics: Phonology (3)

511. Spanish Descriptive Linguistics: Morphology and Syntax (3)

514. Hispanic Dialectology (3) Early fragmentation among the peninsular dialects; origins and descriptive analysis of the American dialects; Judeo-Spanish.

515. Medieval Spanish Literature (3)

518. El Libro De Buen Amor (3)

525. Spanish Renaissance and Golden Age Poetry (3) Lyric poetry, epic poetry, and balladry.

528. Spanish Renaissance and Golden Age Prose (3) Various types of novels with special emphasis on the picaresque; didactic literature; histories.

535. Seminar in Renaissance and Golden Age Literature (3-9) Nature and development of Spanish literature of the 16th and 17th centuries; topics will vary.

538. Theatre of Lope De Vega and His Cycle (3) Major works of Lope de Vega, Tirso de Molina, Guillén de Castro, Mira de Amescua, and others.

539. Theatre of Calderón De La Barca and His Cycle (3) Major works of Calderón de la Barca, Rojas Zorrilla, Augustin Moreto, and others.

540. Cervantes and His Works (3)

543. Spanish Literature of the 18th Century (3) Didactic literature, poetry, drama, and novel in the most representative writers in the century.

550. Spanish Realism (3) The major figures of the period with special emphasis on Pérez Galdós.

560. The Contemporary Novel in Spain (3) The novel since 1941: Cela, Laforet, Zunzunegui, Suárez Carreño, Matute, and others.

563. Contemporary Drama in Spain (3) The drama since 1898, to the present day: Benavente, Valle Inclán, García Lorca, Casona, Buero Vallejo, Sastre, and others.

564. Twentieth Century Hispanic Literature (3-9) Principal trends and works after the Generation of 1898 and *modernismo;* topics will vary.

570. Modernismo (3) The movement, its antecedents, and its followers, with special emphasis on Rubén Darío.

573. Survey of the Spanish-American Novel (3) Trends in the Spanish-American novel, such as *romanticismo, criollismo.*

575. The Spanish-American Essay (3) Tracing the history of ideas in Spanish America through major essayists.

576. Spanish-American Lyric Poetry (3) Aspects of Spanish-American lyric poetry, with emphasis on the 20th century after *modernismo.*

577. Spanish American Drama (3) Dramatic literature in Spanish America from colonial times to the present.

578. Indianismo (3) The Indian as a theme in Spanish-American poetry and prose.

580. History of the Spanish Essay (3) The principal essayists from the 16th century to the present.

581. The Spanish-American Short Story (3) Critical analysis of the major writers and movements from Echeverría to the present.

585. Hispanic Poetry of the 19th and 20th Centuries (3) Various currents in the poetry of the Iberian peninsula and Latin America.

586. Evolution of the Picaresque Hero in Spanish Literature (3) An analysis of the changing character and his environment since Lazarillo to the present day.

598. Seminar in Hispanic Literature (3-12) Common and individual research in special problems in Spanish or Spanish-American literature.

SPEECH (SPCH)

Robert S. Brubaker, *Acting Head of the Department*
305 Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty, Senior Members: Professors Arnold, Brubaker, Holtzman, Nelson, Oliver, Paulson, Schug, and White; Associate Professors Borden, Fife, and Gregg.

Graduate Faculty, Associate Members: Associate Professors Dunham and Hungerford, Assistant Professors Grove and Preston.

The student may specialize in speech arts (interpretation, drama, theatre); radio and television; rhetoric and public address (including discussion, communication,

teaching of speech); speech science (voice, diction, phonetics, general semantics); communicative theory; or international communication. A thesis is required of all M.A. candidates in this major.

The minimum undergraduate preparation required is 12 credits in speech. Students who cannot meet this requirement in full may be admitted but must make up their deficiencies without credit toward the graduate degree. Spch. 400 and 502 are required of all graduate students who do not have their equivalents.

Students who present a 2.75 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

SPEECH (SPCH)

400. Teaching of Speech (3) *Mr. Schug*
402. General Semantics (3) *Mr. Phillips*
410. English Phonetics and Pronunciation (3) *Mr. Brubaker*
412. Speech Criticism (3) *Mr. Arnold*
417. Directing Forensics (3) *Staff*
419. (Journ. 419) Comparative Broadcasting Systems (3) *Mr. Hungerford*
425. Radio Programming and Performance (3) *Mr. Nelson*
431. Anatomy and Physiology of the Ear and Vocal Mechanisms (3) *Mr. Brubaker*
435. Radio and Television Programming (3) *Mr. Nelson*
437. Television Programming and Performance (3) *Mr. Hungerford*
450. Discussion: Research and Theory (2-6) *Messrs. Grove and Phillips*
460. Oriental Rhetoric (3) *Mr. Oliver*
461. Contemporary Public Address in the Far East (3) *Mr. Oliver*
475. Studies in Mass Persuasion in the Democratic Society (3) *Mr. Hager*
477. Contemporary Public Address: the Great Dictators (2) *Mr. Oliver*
478. Contemporary Public Address: English and American Speakers (2) *Mr. Gregg*
485. Advanced Oral Interpretation of Literature (3) *Messrs. Hamilton and Wigley*
490. Psychology of Speaking and Listening (3) *Mr. Holtzman*
494. Teaching of English as a Second Language (3) *Mr Holtzman*
496. Speech for Teachers (3) *Mr. Butt*
498. Directed Study (1-6) *Staff*

500. Seminar in American Oratory (2-6) History of American oratory with application of critical standards to the work of specific orators. *Mr. White*

502. Research Methods in Speech (3) Research design, thesis proposals, and background for research in graduate study. Prerequisite: 6 credits at the 400 or 500 level in speech, clinical speech, or theatre arts. *Staff*

505. Historical Development of Speech Theory and Criticism (2-4) Classical theories of speech-making from the earliest beginnings to the fall of the Roman Empire. *Mr. Arnold*

506. Historical Development of Speech Theory and Criticism (2-4) Theories of speech-making from the Renaissance to the present. *Mr. Arnold*

508. Seminar in British Oratory (2-4) History of British oratory; application of critical standards to the work of selected orators. *Miss Fife*

509. Problems in Rhetoric and Oratory (2-6) Comparative study of selected orators and rhetoricians. Prerequisite: 6 credits in speech. *Mr. Gregg et al.*

510. Problems in Speech Education (2-4) Advanced knowledge, theories, and principles, together with their philosophical, scientific, clinical, artistic, and educational implications for the teacher of speech. Prerequisite: Spch. 502 and 9 additional credits at the 400 or 500 level in speech, clinical speech, or theatre arts. *Mr. Phillips*

520. Seminar in Speech Science (2-4) Seminar in physical and physiological bases of speech and voice; introduction to laboratory techniques used in speech research. Prerequisite: 9 credits in speech, speech pathology and audiology, or psychology. *Mr. Brubaker*

540. Seminar in Problems of Television and Radio (2-4) Study and research in television and radio as they pertain to programming, production, relation to society, and speech. *Mr. Nelson*

550. Seminar in Oral Persuasion (2-4) Theory and devices of persuasion; analysis of persuasive discourse. Prerequisite: 6 credits in speech including Spch. 200. *Mr. Holtzman*

552. Oral Communication in Industry, Business, and Government (2-4) Needs, practices, and methods in American industry, business, and government; methods of training adults in oral communications skills. *Staff*

554. Seminar in Small Group Communication (2-4) Communication variables in small groups. Experimental research and innovations in communication in vocational, therapeutic, and educational groups. *Staff*

555. Speech Communication: Problems and Principles (2-6) Prevalent theories of speech influence. *Messrs. Borden and Phillips*

564. Seminar in European Oratory (2-4) Analysis of significant European speeches with consideration of cultural influences on invention and style. Prerequisite: 6 credits in speech. *Staff*

575. Research Problems in Speech (1-9) Advanced research on an individual basis in oratorical criticism, discussion techniques, persuasion, pedagogy, phonetics, speech science, and speech pathology. Prerequisite: 12 credits in speech or speech pathology and audiology.

SPEECH PATHOLOGY AND AUDIOLOGY (S P A)

Bruce M. Siegenthaler
In Charge of Graduate Programs in Speech Pathology and Audiology
Speech and Hearing Clinic, Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors McDonald and Siegenthaler, Associate Professor Frick.
Graduate Faculty, Associate Member: Associate Professor Berlin.

Students may specialize in speech pathology, audiology, or deaf education. Students who present a 3.00 (2.50 for deaf education) junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Required are 24 credits dis-

tributed among speech pathology, audiology, speech science, psychology and related areas (including one statistics course; tests and measurements for deaf education), and letters of recommendation. Exceptions may be made for students with special backgrounds, abilities, and interests.

The degree programs include the requirement of a number of field trips to diagnostic and treatment facilities, and may include a period of internship at an off-campus location. Students should expect to have moderate expenses related to these trips.

SPEECH PATHOLOGY AND AUDIOLOGY (S P A)

430. Introduction to Audiology (3)
433. Methods in Auditory Training and Speech Reading (3)
434. Pure Tone Audiometry (3)
439. Practicum in Auditory Training and Speech Reading (1-5)
440. (E.E.C. 440) Survey of Speech and Hearing Disorders (3)
441. Current Problems in Speech Pathology and Audiology (1-6)
442. Speech Pathology: Articulation and Stuttering (3)
444. Speech Pathology: Voice and Organic Disorders (3)
445. Professional Programs and Relationships (3)
449. Practicum in Speech Therapy (1-6)
460-461. Teaching Speech to the Deaf (2 each)
462-463. Teaching Language to the Deaf (3 each)
464-465. Teaching Elementary School Subjects to the Deaf (2 each)
466. Problems in Education and Guidance of the Deaf (3)
469. Student Teaching with the Deaf (3-12)

530. Seminar in Audiology (1-6) Review of theories of hearing and review of related physiological and psychological researches. Prerequisite: S.P.A. 434.

531. Speech Audiometry and Hearing Aids (3) Techniques and interpretation of speech reception tests; hearing aids and hearing aid advisement procedures; observations and practice in test administration. Prerequisite: S.P.A. 434.

532. Acoustical Instruments for Hearing (3) Acoustical instrumentation used for research in hearing, programs of hearing conservation, and noise control, including clinical and industrial applications. Prerequisite: 6 credits in acoustics, audiology, experimental psychology, or speech science at 400 level.

538. Practicum in Audiologic Evaluation and Selection of Hearing Aids (1-5) Prerequisite: S.P.A. 531.

540. Articulation Disabilities (3) Speech-sound production disorders in children and adults; methods of examination, diagnosis, and treatment. Prerequisites: S.P.A. 442, 449.

541. The Voice and Its Disorders (3) Physical, physiological, and psychological bases of voice production; causes, nature, and symptoms of its disorders; current clinical methods in voice improvement. Prerequisites: S.P.A. 444, 449.

542. Stuttering (3) Modern theories of causes of disorders of rhythm; methods of examination, diagnosis, and treatment. Prerequisites: S.P.A. 442, 449.

543. Diagnostic Procedures in Clinical Speech (3) Clinical instrumentation; case history taking; examination procedures and materials used in diagnosing speech disabilities; interpretation of findings; report preparation. Prerequisite: S.P.A. 444.

544. Cleft Palate (3) Anatomy, physiology, embryology, and growth of the palate and contiguous structures; etiology, diagnosis, habilitation of cleft palate problems. Prerequisite: S.P.A. 444.

545. (E.E.C. 545) Cerebral Palsy (3) Etiology and symptomatology of cerebral palsies; diagnosis and treatment of communication problems; the multi-professional habilitative program. Prerequisite: S.P.A. 444.

546. (E.E.C. 546) Aphasia and Allied Disorders (3) Aphasia and related disorders in adults and children: etiology, diagnosis, and treatment. Prerequisite: S.P.A. 444.

548. Practicum in Speech Diagnosis (1-3) Supervised practice in interviewing, counseling, speech evaluation, and synthesis of psychological medical and audiological data in speech diagnosis; report writing. Prerequisites: S.P.A. 444, 449.

549. Advanced Practicum in Speech Therapy (1-6) Theoretical and clinical rationale of therapy; profesional role and relationships; therapy procedures, individual and group; evaluation of process and outcomes. Prerequisites: S.P.A. 442, 449.

550. Seminar in Speech Pathology (1-6) Advanced study of special problems and new developments in speech pathology. Prerequisites: S.P.A. 442, 444.

STATISTICS (STAT)

William L. Harkness, *Acting Head of the Department*
333 McAllister Building

Degrees Conferred: Ph.D., M.A., M.S.

Graduate Faculty, Senior Members: Professors Bartoo and Patil; Associate Professors Antle, Harkness, and Hultquist.

The modern science of mathematical statistics is concerned with the general principles of dealing with uncertainty and partial ignorance. Of fundamental importance to the discipline is the theory of probability, which is the study of mathematical models of random phenomena. Basic courses in statistics and probability are offered regularly.

While applications from all students (including those who already have done graduate work) are reviewed, completion of a standard calculus sequence is regarded as a prerequisite. Students who present a 3.00 junior-senior average or better will be acceptable to the department provided they have the stated prerequisites and subject to the limitations of the departmental facilities. No special areas of specialization are required, though further work in mathematics would be desirable. Exceptions may be made for students with special backgrounds, abilities, and interests.

For the M.A. degree, the candidate must complete 30 course credits, with at least 18 credits (15 in statistics) of 500-series courses, Math. 421, and Math. 441 or 481 in addition to a term paper. For the M.S. degree, 12 credits of 500-series statistics courses, 6-9 credits of thesis, Math. 421, and Math. 441 or 481 are required.

Ph.D. candidacy is contingent upon passing three written qualifying examinations and a reading examination in French, German, or Russian. Completion of a second of these languages or a demonstration of proficiency in computer science is necessary before the comprehensive examination (taken after approximately 60 credits) is given.

STATISTICS (STAT)

401. Statistical Methods I (3)
402. Statistical Methods II (3)
403. Statistical Methods III (3)
409-410. (Math. 409-410) Introduction to Mathematical Statistics (3 each)

411. Practicum (1)
418. (A.M. 418, Math. 418) Discrete Probability Theory (3)
490. Special Topics in Probability and Statistics (3-9)

501. Theory of Statistics (3) Sufficiency and completeness, testing hypotheses, sequential analysis, chi-square tests, analysis of variance. Prerequisite: Stat. 410.

502-503. Analysis of Variance and Regression (3 each) Linear hypotheses, regression, analysis of variance and covariance, mixed and random effects models, multiple comparisons, designs. Prerequisites: Stat. 410; Math. 441 or 481.

504. Nonparametric Statistics (3) Goodness-of-fit tests, contingency tables, anaysis of multinomial and percentage data, multi-sample problems, special topics. Prerequisite: Stat. 410.

505. Multivariate Statistical Analysis (3) Statistical procedures associated with the multivariate normal distribution. Prerequisites: Stat. 410; Math. 441 or 481.

506. Sampling Theory (3) Theory and application of sampling from finite populations. Prerequisite: 6 credits in statistics.

507. Sequential Analysis (3) A thorough discussion of sequential procedures of estimation and testing of hypotheses. Prerequisite: Stat. 554.

508. Characterization of Statistical Models (3) Characteristics of different statistical distributions; characterizations of distributions through structural properties and statistical procedures. Prerequisites: Stat. 518, 543.

509. Discrete Statistical Models and Methods (3) Systematic study of probability models and statistical methods pertaining to statistical analysis of data consisting of single and multiple counts. Prerequisite: Stat. 554.

512-513. (A.M. 512-513) Introduction to Stochastic Processes (3 each) Markov chains, random walk and recurrent events, queuing theory, time-dependent stochastic processes. Prerequisite: Stat. 418.

517-518. (Math. 517-518) Probability Theory (3 each) Measure theoretic foundation of probability, distribution functions and laws, types of convergence, central limit problem, conditional probability, special topics. Prerequisites: Math. 452, 501.

542-543. (Math. 542-543) Statistical Distribution Theory (3 each) Random variables and expectations; discrete, continuous, univariate, multivariate, exact, and asymptotic distribution theory. Prerequisites: Math. 421 and 441 or 481.

553. Statistical Estimation and Testing I (3) Point estimation of one parameter; sufficiency; completeness; maximum likelihood; interval estimation. Prerequisite: Stat. 543.

554. Statistical Estimation and Testing II (3) Neyman-Pearson theory and lemma; uniformly most powerful tests; unbiased tests; large sample procedures. Prerequisite: Stat. 553.

558-559. (Math. 558-559) Theory of Stochastic Processes (3 each) Stationary, independent, and orthogonal processes, discrete and continuous Markov processes, martingales and semi-martingales applications. Prerequisite: Stat. 518.

561. Statistical Inference I (3) Multiparameter estimation; linear estimation; maximum likelihood estimation; Bayesian estimation; large sample properties and procedures. Prerequisite: Stat. 554.

562. Statistical Inference II (3) Testing statistical composite hypotheses; invariance principles; Bayesian statistics; large sample properties and procedures. Prerequisite: Stat. 561.

572. Statistical Decision Theory I (3) Structure of statistical games; optimal strategies, fixed sample-size games. Prerequisites: Math. 502, Stat. 561.

573. Statistical Decision Theory II (3) Sufficient statistics; the invariance principle; estimation and testing. Prerequisite: Stat. 572.

577. (Math. 577) Special Topics in Probability (3-12) Special topics in probability which are not offered regularly but which are of special interest to faculty and students.

590. Seminar in Statistical Methods (1-6) Lectures on current statistical methods; presentation and discussion of literature treating various special topics in statistics.

591. (Math. 591) Seminar in Probability Theory (1-6) Lectures on current and recent research in various special topics in probability theory.

592. Special Topics in Statistics (3-12) Special topics in statistics which are not offered regularly but which are of special interest to faculty and students.

THEATRE ARTS (THEA)

William H. Allison, *Head of the Department*
103 Arts Building

Degrees Conferred: M.A., M.F.A.

Graduate Faculty, Senior Members: Professors Smith and Walters; Associate Professors Manfull, Reifsneider, and Yeaton.

Graduate Faculty, Associate Members: Associate Professor Allison, Assistant Professors Shank and Wells.

The M.A. program is planned to provide breadth of studies in theatre. A thesis in some area of specialization is required.

Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

Requirements for admission to the M.A. program are:

1. A broad undergraduate preparation in theatre, including courses in basic acting, directing, theatre crafts, and theatre history (or their equivalents as indicated by evidence of practical experience in the theatre).
2. Eighteen credits in related subject areas, such as oral interpretation, dramatic literature, music, and art.

The M.F.A. program is planned to provide a professional emphasis. Specialization in the following areas is stressed: performance (acting or directing); production (scene design, costuming, lighting, or technical direction); or playwriting. A required final project in the area of specialization includes a monograph.

Requirements for admission to the M.F.A. program are:

1. Twenty-four credits in theatre arts, including one course each in acting, directing, and theatre crafts. Related courses in the student's area of specialization may be accepted.

2. All students are to submit evidence of ability in their areas of specialization under arrangements to be made with the department. Auditions, prompt books, portfolios, manuscripts, and other appropriate presentations are to be submitted by applicants to the various study programs.
3. Vitae and letters of recommendation (at least three) are to be submitted.
4. Personal interviews should be arranged by all students.

All students in the M.A. and M.F.A. programs who are deficient in the required undergraduate courses may be requested to take additional course work in the areas of deficiency without degree credit.

Under certain circumstances the Ph.D. degree is offered by the Department of English with specialization in drama and minor work in theatre arts.

All graduate majors are required to participate in University Theatre productions in positions of responsibility.

401. History of Ancient and Medieval Theatre (3)
402. History of Renaissance and Oriental Theatre (3)
403. History of Modern European and British Theatre (3)
405. History of American Theatre (3)
410. Creative Dramatics with Children (3)
411. Projects in Creative Dramatics (2)
416. Children's Theatre (3)
417. Staging Theatre for Children (3)
418. Marionettes and Puppetry (3)
424. Dance for the Theatre (3)
425. Dance for the Contemporary Musical Theatre (2-6)
427. Theatre Makeup (2)
429. Theatre Performance Practicum (1-6)
434. Directing (3)
435. Rehearsal Methods for the Director (3)
436. Central Staging (3)
445. Advanced Playwriting (3-6)
450. Advanced Scene Design (3-6)
460. Costume Design (3)
461. Costume Construction (3)
462. Drafting Historical Costumes for the Stage (2)
474. Stage Lighting (3)
479. Stage and Production Management (3)
485. Sound for Theatre Production (3)
489. Theatre Production Practicum (1-3)
490. Motion Picture Techniques (3-6)
491. The European Film (3)
492. The American Film (3)
495. Performance for the Camera (3)
496. Radio and Television Directing (3)

500. Theatre Research: Sources and Procedure (1) Materials and techniques as applied to theatre research; the form and content of theses and monographs.

503. Theatre Criticism and Theory (3)

505. Theatre History (3) Specific aspects of theatre from ancient times to the present.

522. Acting I (4) Interpretation of theatrical styles: the tradition of tragedy; voice and movement.

523. Acting II (4) Interpretation of theatrical styles: the tradition of comedy; voice and movement. Prerequisite: Thea. 522.

524. Acting III (4) Interpretation of theatrical styles: forms of modern realism; voice and movement. Prerequisite: Thea. 523.

525. Acting and Directing Theory (3) The actor and director as related to cultural environment from the Greek theatre through the post-Stanislavskian theorists.

530. Play Interpretation for the Director (3) Theory and practice in the analysis and implementation of story, style, and form.

531. Special Forms in Directing (3) Applied theory and techniques for various genres and periods of drama. Prerequisite: Thea. 530.

533. Projects in Directing (1-6 per term)

535. Experimental Theatre (1-3) Operational research and experimental methods in the preparation, planning, execution, observation, and evaluation of production.

540. Playwriting (3-6) Focus on problems in writing the full-length script through seminar, play reading, and individual session.

543. Projects in Playwriting (1-9) Preparation of the script for revision during and rewriting following production of the student's original play. Prerequisite: production approval.

553. Design and Technical Production (1-6 per term) Special projects in design and technical execution of scenery, costumes, lighting, sound, and special effects.

560. Costume Design (3-6) Design concepts, rendering, and execution of costumes for the stage.

574. Lighting for Theatre Production (3) Design techniques for production in arena, thrust, and proscenium theatre situations.

580. Theatre Technology (3) Design consultation and specification of equipment, systems, and movable structures for new theatres; structures and projection devices for production.

582. Theatre Administration (3) The theatre: organization and management.

583. Projects in Theatre Administration, Management, and Operations (1-6)

585. Theatre Planning (3) Processes and problems in planning and designing theatres: performance, audience, and technical requirements.

590. Special Problems in Film and TV (1-3 per term)

VETERINARY SCIENCE (V SC)

Alfred L. Bortree, *Head of the Department*
115D Animal Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Bortree, Dunne, and Gentry; Associate Professor Rothenbacher.

Graduate Faculty, Associate Members: Professor Swope; Assistant Professors Eberhart, Scholz, and Zarkower.

Areas of specialization include veterinary pathology, veterinary physiology, and veterinary microbiology. There is opportunity for cooperative research with other departments in animal science, microbiology, and physiology. Unless excused by specific departmental action, all doctoral candidates must attain the master's degree as a step toward candidacy for the Ph.D. degree. A thesis is required of all candidates for the M.S. degree.

Proficiency in reading one foreign language is required. In the case of foreign students whose native language is other than English, this requirement may be waived with the approval of the doctoral committee.

Prerequisites for admission are a veterinary degree or a bachelor's degree in a related biological field. Adequate preparation in the basic sciences compatible with the candidate's objectives is required. Students may be admitted with limited deficiencies and are required to remove undergraduate deficiencies without degree credit.

The candidate with the bachelor's degree only must have maintained during his junior and senior years a 2.50 grade point average. Exceptions may be made for students with special backgrounds, abilities, and interests. Academic records of candidates with the Doctor of Veterinary Medicine degree or M.S. degree will be reviewed and acted on by the graduate faculty of the department.

VETERINARY SCIENCE (V SC)

401. Ecology of Animal Disease (3)
405. Laboratory Animal Science (3)
420. General Animal Pathology (3)

515. Virology (2-4) Rickettsial and viral agents parasitizing man, animals, and microorganisms. Prerequisite: Micrb. 410.

520. Histopathology (3) Specific microscopic alterations and reactions developing in the living animal body when exposed to injurious agents or deprivations.

525. Mechanisms of Hypersensitivity and Immunopathology (3) Concepts of hypersensitivity and special consideration of immunopathological conditions. Prerequisites: Biol. 437, Micrb. 410, and 3 credits of pathology.

528. Diagnostic Pathology (3-9) Gross examination of animals and birds, their tissues and body fluids for pathologic changes. Prerequisites: 6 credits in pathology, microbiology, or infectious diseases.

535. Acquired and Congenital Disorders of Metabolism (3) Abnormalities and alterations in metabolism due to dysfunctions of animal organs. Prerequisites: 6 credits in general biochemistry and 3 credits in animal physiology.

581. Seminar in Veterinary Science (1-4) Presentation and critical discussion of results of personal research or topics of current interest.

582. Special Problems (1-9) Investigation of special disease problems, including laboratory and field studies.

VOCATIONAL INDUSTRIAL EDUCATION (VI ED)

Joseph T. Impellitteri
In Charge of Graduate Programs in Vocational Industrial Education
248 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

VOCATIONAL INDUSTRIAL EDUCATION

Graduate Faculty, Senior Members: Professor Brandon, Associate Professor Impellitteri.
Graduate Faculty, Associate Members: Professor Williams, Associate Professors Brantner and Gillie.

Emphasis may be placed upon preparation for teaching, supervision, administration, or teacher education. Graduation from an approved major in industrial education is required for admission.

Students who present a 2.50 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

INDUSTRIAL EDUCATION (I ED)

402v. Supervision of Vocational Education (3)
403v. Supervised Field Work (6)
408v. Occupations (3)
409v. Tests and Measurements (3)
412v. Special Problems in Vocational Education (6)
415v. Problems in Coordinating Vocational Education (3)
420v. Occupational Hygiene (3)
427v. Advanced Course of Study Building (3)
446v. Improvement of Instruction in Vocational Education (4)
450v. Shop Layout and Management (3)

501v. Seminar in Vocational Education (6) Conferences, investigations, and discussion for advanced students and mature persons who have had experience as teachers, supervisors, or administrators.

506v. Administration of Vocational Education (3) The job of the local director of industrial education in organizing and developing city and other local programs of industrial education. Prerequisite: 6 credits in industrial education, valid director's certificate, or equivalent training and experience.

510v. Vocational Education for Administrators (3) Designed for school administrators and supervisors who desire an understanding of practical arts and vocational education. Prerequisite: I.Ed. 1v or trade or teaching experience.

550v. Research in Vocational Education (3) Research techniques in vocational industrial education.

556v. Federal Legislation (2-3) Recent federal legislative activities and executive orders that bear directly and indirectly upon industrial education.

557v. Present-Day Local, Personnel, and Curriculum Problems (2-3) Various plans, techniques, and practices.

558v. State and Local Supervision and Administration (2-3) The more important recent problems in organization, supervision, and administration.

559v. Vocational Technical Education (2-3) Problems of organization and administration of programs of technical education at the secondary and post-secondary levels. Prerequisite: 6 credits in industrial education, valid director's certificate, or equivalent training and experience.

560v. Philosophy of Industrial Education (3) Principles and beliefs of progressive industrial education; literature for evaluating instructional practices. Prerequisite: 12 credits in industrial education or teaching experience.

WILDLIFE MANAGEMENT (W L M)

WILBER W. WARD, *Director of the School of Forest Resources*
101 Ferguson Building
or
TIEN-HSI CHENG, *Professor of Zoology*
208 Life Sciences Building

Degree Conferred: M.S.

Graduate programs in the field of wildlife management are offered by the Department of Forestry and Wildlife for students primarily interested in the habitat aspects, and by the Department of Biology for those primarily interested in the animal aspects.

See admission requirements under respective majors.

ZOOLOGY (ZOOL)

TIEN-HSI CHENG
In Charge of Graduate Programs in Zoology
208 Life Sciences Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Anthony, Cheng, Cooper, Dalton, and Hale; Associate Professors Bellis, Butler, Hibbard, Hymer, and Wickersham; Assistant Professors Dunson and Henshaw.

Graduate Faculty, Associate Members: Associate Professor Wood, Assistant Professors Abplanalp and Neff.

Zoological programs are offered in animal behavior, cell biology, developmental biology, ecology, endocrinology, fishery biology, genetics, histology, ichthyology, invertebrate zoology, morphology, physiology, population dynamics, or wildlife management. The bachelor's program must show emphasis on zoological subjects and include adequate preparation in mathematics and physical sciences. Each applicant must provide Graduate Record Examination scores, letters from two persons most familiar with his academic qualifications, and a personal statement of his primary interests and objectives.

A limited deficiency may be made up without degree credit while pursuing graduate work. Students who present a 2.80 junior-senior average will be acceptable to the department provided they have appropriate course background and subject to the limitations of the departmental facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

See also Genetics and Physiology.

NOTE: *For courses in Zoology and related subjects see Biology.*

OTHER ELECTIVE GRADUATE COURSES

The following courses are in fields in which neither major nor minor work is offered at this institution. The courses, however, carry graduate credit and, with the approval of the major department, may be applied toward the requirements for a degree either as elective courses or as a part of a general studies program. The usual restrictions upon the use of 400 series courses in degree programs apply to these courses.

AGRICULTURE, GENERAL (AG)

400. Introductory Biometry (3) *Mr. Bennett*

AMERICAN STUDIES (AM ST)

402. Seminar in American Studies (3-9)

ANIMAL SCIENCE (AN SC)

422. Quantitative Inheritance and Animal Breeding (3) *Mr. Hicks*

APPLIED MATHEMATICS (A M)

405. (Math. 405) Fourier Series and Partial Differential Equations (3)
417. (Math. 417) Tensor Analysis (3)
418. (Math. 418, Stat. 418) Discrete Probability Theory (3)
419. (Phys. 419) Theoretical Mechanics (3)
431. (Math. 431) Ordinary Differential Equations (3)
441. (Math. 441) Matrix Algebra (3)
451. Functions of Several Variables (3)
452. (Math. 452) Functions of a Complex Variable (3)
461. (Phys. 461) Theoretical Mechanics (3)
490. Special Topics (1-12)

510-511. Linear Methods (3 each) Matrices, quadratic forms, ordinary and partial differential equations, integral equations, transforms, Fourier series. Prerequisite or concurrent: A.M. 452.

512-513. (Stat. 512-513) Introduction to Stochastic Processes (3) Markov chains, random walk and recurrent events, queuing theory, time-dependent stochastic processes.

520. Asymptotic Techniques in Differential Equations (3) Asymptotic series; applications to ordinary and singular perturbation problems. Prerequisite: A.M. 511.

540. Magnetohydrodynamics (3) The mathematical description of the interaction of an electrically conducting fluid with electromagnetic fields. Prerequisites: A.M. 511, Phys. 557.

550. (Phys. 550) Applied Group Theory (3) Representations of discrete and continuous groups, applications to theoretical physics and differential equations, varying emphasis on the specific applications. Prerequisite: A.M. 510.

555. Introduction to Group Representations (3) An introduction to matrices, groups, group representations, characters, and orthogonal functions, with orientation to chemistry and physics.

590. Special Topics (2-12) Various topics according to instructor and students. Prerequisite: second-year graduate standing.

THE ARTS (ARTS)

400. The Arts (3)

CHINESE (CHNS)

498. Readings in Chinese (1-6)

COMMUNITY DEVELOPMENT (COM D)

401. Socioeconomic Change and the Process of Dislocation (3)
402. Politics, Policy, and Community Action (3)
403. Ideal Communities (3)
404. Interpersonal and Group Processes in Community Change (3)
405. Community Mental Health: An Ecological Approach to Human Services (3)
406. Planning and Evaluating Human Service Programs (3)
407. Community Conflict (4)
417. Identifying Community Power Structures (3)
418. Community Organizing (5)
419. Comparative Community Development (3)

CONSUMER STUDIES (C S)

420. Consumer Industries (4)
430. Societal Aspects of Consumer Problems (2)

CULTURAL FOUNDATIONS OF EDUCATION (CF ED)

416. (Soc. 416) Sociology of Education (3)
417. Philosophic Basis of Education (3)
418. History of Education in the United States (2-3)
419. History of Education in Ancient and Medieval Times (3)
420. History of Modern European Education (3)
422. Introduction to Comparative Education (3)

515. Experimentalist Philosophies of Education (2-3) John Dewey's educational philosophy and later formulations by Bode, Kilpatrick, Childs, Brameld, and others. Prerequisite: C.F.Ed. 417 or 6 credits in philosophy.

516. Topical Seminar on School and Society (2-6) An intensive and comprehensive analysis of one selected aspect of the relationship of educational institutions to their societal setting. Prerequisite: C.F.Ed. 416.

519. Contemporary Philosophies of Education (2-3) Implications for education of various types of Realism, Idealism, Existentialism, and Analytic philosophy. Prerequisite: C.F.Ed. 417 or 6 credits in philosophy.

520. Comparative Philosophies of Education (2-3) Effect of ideologies on education in selected national systems; emphasis on relationships between theory and educational practice. Prerequisite: C.F.Ed. 417 or 6 credits in philosophy.

521. Education in the Latin-American Countries (2-3) Recent educational progress in Central and South America, with special reference to Mexico, Cuba, Puerto Rico, Brazil, Chile, and Argentina. Prerequisite: C.F.Ed. 422 or 6 credits in Latin-American studies.

522. Comparative European Education (2-3) Educational policies and practices in school systems in western and central European nations. Prerequisite: C.F.Ed. 422.

524. Education in Communist Countries (2-3) Educational policies and practices in Soviet Russia and other Communist countries. Prerequisite: C.F.Ed. 422 or 6 credits in Russian or Asian studies.

526. Education in Developing Countries (2-3) Educational problems and trends in selected countries, with particular reference to Africa, the Middle East, and Southeast Asia. Prerequisite: C.F.Ed. 422 or 6 credits in Asian, African, or Latin-American studies.

528. Education in Canada (2-3) Development and organization of education in the Canadian provinces; emphasis on dual systems of Ontario and Quebec. Prerequisite: C.F.Ed. 422.

532. Social Change, Cultural Dynamics, and Education (2-3) The social role of the school in a rapidly changing society. Prerequisite: C.F.Ed. 416.

534. Readings in Philosophy of Education (1-6) Selected philosophic writings—classic, modern, or contemporary—on education. Prerequisite: C.F.Ed. 417 or 6 credits in philosophy.

536. Educational Leaders and Classics (2-3) Selected leaders and their writings, with emphasis on historical-social context, including Quintilian, Erasmus, Comenius, Feelon, Pestalozzi, and Mann.

592. Seminar in Cultural Foundations of Education (1-9) Conferences and discussions designed to meet the need for special study of particular areas in cultural foundations of education. Prerequisites: 12 credits of graduate work in cultural foundations of education.

EDUCATIONAL SERVICES (EDSER)

450. Visual and Other Aids in Safety Education (3)
451. Teaching Traffic Safety and Automobile Operation (3)
452. Organization and Supervision in Safety Education (3)

ENGINEERING (ENGR)

450. Patent Fundamentals (3)

500. Special Topics in Engineering (1-3)

531. Advanced Digital Computer Programming (3) Nonnumerical applications; symbol manipulation, syntactical analysis, and translation of artificial languages; heuristic methods, learning mechanisms, artificial intelligence.

ENGINEERING GRAPHICS (E G)

421. Engineering Graphics for Teachers (3)

HEALTH PLANNING AND ADMINISTRATION (H P A)

410. Principles of Public Health Administration (3)
430. Principles of Health Planning (3)
431. Health Planning Methods (3)
432. Health Services Evaluation (3)

HOUSING AND INTERIORS (H I)

410. Textile Design I (3)
411. Textile Design II (3)
412. Textile Design III (3)

HUMAN DEVELOPMENT (H DEV)

400. Special Problems in Human Development (1-6)
401. Professional Issues in Human Development (1-3)
499. Senior Thesis (1-10)

516. Methods of Research in Human Development (3) Review of problems and techniques of research in human development.

HUMANITIES (HUMAN)

490. (Sec.Ed. 490) The Teaching of the Humanities (3)

INSTRUCTIONAL MEDIA (INSTM)

435. Orientation to Instructional Media (2)
436. Production and Utilization of Graphic Stimulus Materials (3)
437. Production of Educational Motion Pictures (3)
443. Television in Education (3)

531. Organization and Administration of Media in Schools (2) Problems of providing instructional media in schools; the role of the media consultant in curriculum construction. Prerequisite: Inst.M. 435.

INTERNATIONAL UNDERSTANDING (INT U)

400. World Affairs and International Understanding (3-6)

ITALIAN (IT)

598. Seminar in Italian Literature (3-12) Common and individual research in special problems.

LABOR-MANAGEMENT RELATIONS (L M R)

400. Comparative Industrial Relations Systems (3)
411. Trade Union Administration (3)
414. (Econ. 414) Theories of the Labor Movement (3)
415. Labor Movements in Developing Areas (3)
421. Labor Education (3)
433. (Pl.Sc. 433) The Law of Labor-Management Relations (3)
454. (Soc. 454) Industry and the Community (3)
455. (Soc. 455) Occupations and Professions (3)
456. (Hist. 456) History of American Labor (3)
457. (Soc. 457) Field Work in Industrial Society (1-6)
498. Problems in Labor Studies (1-9)

LANDSCAPE ARCHITECTURE (LARCH)

420. Landscape Ecology (3)
425-426. Landscape Construction Problems (3 each)

LANDSCAPE ARCHITECTURE

427. Landscape Construction Problems (2)
434. Urban Park and Recreation Areas (3)
454-455. Landscape Design (3 each)
460-461-462. Advanced Landscape Design (4-8 each)
471. Park Systems (2)
472. Planning and Public Policy (3)
473. Recreation Resource Planning (3)
474. Site Engineering Fundamentals (1)

518. Advanced Problems in Landscape Design (2-12) Selected problems for original investigation in the design, construction, and maintenance of landscape architectural projects.

521. Technical Landscape Architectural Practices (2-12) Specific technical and professional problems in landscape architectural planning and practice. Prerequisites: L.Arch. 462, 471.

LAW ENFORCEMENT AND CORRECTIONS (L E C)

401. Probation, Parole, and Pardons (3)
410. Correctional Counseling Processes (3)
430. Correctional Institutions and Services (3)
470. Law of Crimes and Corrections (3)
480. Research Literature on Crime and Corrections (3)

LIBERAL ARTS (L A)

498. Undergraduate Seminar: Selected Topics (3-9)

LINGUISTICS (LING)

400. Introduction to Transformation Grammar (3)
401. Advanced Psycholinguistics (3)
402. Historical Linguistics (3)

500. Generative Linguistics (3) Types of grammatical rules and their interrelations; algorithm for assigning structural descriptions; evaluation procedure for selecting best compatible grammar.

501. Seminar in Psycholinguistics (3) The relationship between the behavioral, probabilistic view and the structuralist, deterministic view of language as a system of habits.

503. Generative Syntax (3) Grammatical rules specifying well-formed strings; conditions on analyzability and assigning of structural descriptions; deviation from well-formedness. Prerequisite: Ling. 400.

504. Generative Phonology (3) Distinctive feature theory in the generative framework; articulatory and acoustic correlates; nonphonemic features. Prerequisite: Ling. 400.

505. Seminar in Historical Linguistics (3) Detailed study of some problem of historical linguistics, e.g., the laryngeal theory, Indo-European ablaut, etc. Prerequisite: one course in historical linguistics.

LITHUANIAN (LITH)

500. Structure of Lithuanian (3) Analysis of the phonology, morphology, and syntax of Lithuanian; comparative linguistic study of Balto-Slavic and Indo-European. Prerequisite: 1 graduate course in linguistics.

MATERIALS SCIENCE (MATSC)

401. Materials Science for Teachers (3)
411. (Min. 411) Instrumental Techniques Applied to Materials and Mineral Science Problems (1-3)
Unit A. X-ray Diffraction
Unit B. Electron Microscopy
Unit C. Spectroscopy
Unit D. Electron Probe Analysis
420. Mathematical Modelling for Materials Scientists (3)
421. (Min. 421) X-ray Diffraction (3)
431. (Min. 431) Instrumentation for Physical Measurement and Control (3)

512. (Gchem. 512) Principles of Crystal Chemistry (2-4) Relation of structure to ionic size and nature; influence of pressure and temperature on structure; chemical-structural defects, crystalline solutions, phase-transitions.

514. Characterization of Materials (3) Classical and new (microprobe, scanning microscope, magnetic resonance, and Mossbauer) techniques for the characterization of composition, structure, defects, and surfaces.

531. (Min. 531) Electron Transmission Microscopy in the Materials and Mineral Science (3) Discussion of electron image contrast theory as a tool for study of atomic substructures in the materials and mineral sciences.

532. (Min. 532) Structure Analysis (2) Crystal structure determination methods: space groups, structure factors, heavy atoms and isomorphous replacement, Fourier synthesis, Patterson maps, inequalities, refinement techniques. Prerequisite: Mat.Sc. (Min.) 421.

533. (Min. 533) Single Crystal Methods (2) Experimental techniques in crystal structure determination: crystal selection, space group determination, measurement of intensities, analysis of data. Prerequisite: Mat.Sc. 421 or Min. 421.

535. (Min. 535) Geometrical Crystallography (2) Derivation of lattices, types, point groups and space groups with applications.

550. Evaporation and Condensation of Solids (2) Thermodynamics of evaporation and condensation of solids; condensation processes including thin films and epitaxial growth and their applications.

552. Theory and Practice of Crystal Growth (3) Theoretical approaches to crystal growth and of the various techniques used in growing crystals.

590. Special Topics in Materials Science (1-6) Intensive group study of special topics.

MINERAL SCIENCES (MN SC)

513. Semiconductor Physics (3) Electronic structure of solids; electronic transport phenomena; semiconductor materials; luminescence. Prerequisite: Phys. 400 or E.E. 32. *Mr. Henisch*

POLISH (POL)

501. Readings in Polish Literature (3-6) Individual reading and research in nineteenth and twentieth century Polish literature and literary criticism.

PORTUGUESE (PORT)

598. Seminar in Portuguese and Brazilian Literature (3-12) Common and individual research in special problems.

RELIGIOUS STUDIES (RL ST)

402. Seminar in Contemporary Religious Thought (3-6)
408. Hinduism (3)
409. Buddhism (3)
421. Culture and Religious Reform (3)
430. Religion and Morality (3)
438. (Soc. 438) Religion and Urban Society (3)
440. Problems in Religion (3-6)
461. (Soc. 461) Sociology of Religion (3)

502. Studies in Comparative Religions (3-6) Cross-cultural comparative studies of two or more major world religions.

505. Seminar in Asian Religions (3-6) Studies in selected Asian religions.

520. Early and Medieval Western Religion (3-6) Studies in Judaism and Christianity from the 1st century A.D. to 1500.

530. Religion and Society (3-9) Studies of mutual influences and effects of religious and secular phenomena.

THE MILTON S. HERSHEY MEDICAL CENTER (H M C)

GEORGE T. HARRELL, JR., *Dean of the College of Medicine*
Director, The Milton S. Hershey Medical Center
Hershey, Pennsylvania 17033

Graduate Faculty, Senior Members: Professors Davidson, Lurie, Morgan, Munger, Naeye, Pattishall, Rapp, and Vesell; Associate Professors Baird, Fritz, Greene, Ha, Hass, Jones, Morgan, Mortimore, and Rosenberg; Assistant Professors Davis and B. Pubols.

Graduate Faculty, Associate Members: Associate Professors Krieg and Offord; Assistant Professors Blackburn, Connor, Egeland, Funk, Hill, Houts, Jefferson, Jones, Lang, Lausch, Miljkovic, Murray, Neely, Severs, Thompson, and Wolfe; Mrs. L. Pubols.

Graduate Faculty, Lecturers: Assistant Professors Benjamin, Kreider, Shiman; Lecturer Patterson.

ANATOMY (ANAT)

501. GROSS HUMAN ANATOMY (3) Macroscopic organization of the extremities and head and neck with emphasis on anatomical individuality, functional significance, and clinical correlations.

502. GROSS HUMAN ANATOMY (3) Macroscopic organization of the abdomen, thorax, and pelvis with emphasis on anatomical individuality, functional significance, and clinical correlations.

505. MICROSCOPIC ANATOMY (3) Microscopic organization of tissues and cells; interrelationships of cells; chemical and functional specializations of cells.

510. NEUROBIOLOGY (3) Morphology and function of the sense organs, general organization of the brain, and physiological studies of central nervous system function.

512. HUMAN EMBRYOLOGY (2) Detailed study of normal development and physiology of the embryo and fetus; attention to developmental anomalies and fertilization problems.

530. DISSECTION (2-4) Individual dissection of a particular region of the body, study of the pertinent literature, and preparation of a report.

535. SUBMICROSCOPIC ANATOMY (3) Current literature on molecular and micellar organization of cells and tissues in diverse systems; application of interference and electron microscopy.

540. SEMINAR (1 per term) Student and staff presentations designed to evaluate current research developments in anatomy.

542. COMPARATIVE NEUROLOGY (3) A study of comparative aspects of central nervous system organization as related to phylogenetic development. Prerequisite: Anat. 510.

543. THE PERIPHERAL NERVOUS SYSTEM (3) A study of the somatic sensory and motor systems. Prerequisite: Anat. 510.

545. COMPARATIVE VERTEBRATE OTOLOGY (3) Evolution and principles of the auditory system demonstrated by comparison of structures in ears of vertebrates; independent study expected.

550. SEMINAR IN QUANTITATIVE OPTICS (3) Study of the various types of light

microscopy instruments and application of these tools to quantitative measurements in biological systems. Prerequisite: Anat. 505.

570. Special Topics (1-6) Introduction of students to the research laboratory and scholarly pursuits of members of the staff; credit arranged by consultation.

590. Research Problems (1-12) Individualized research conducted by students in departmental laboratories. The program and credits to be arranged by consultation.

BEHAVIORAL SCIENCE (BEHSC)

501. Behavioral Science (4) Integration of bio-psycho-social substrates of behavior, variability in behavior during development, and behavioral correlates with disease and health.

502. Behavioral Science (3) Continued integration of bio-psycho-social substrates with emphasis on adaptation, during development, and behavioral correlates with disease and health.

503. Behavioral Science (3) Continued integration of behavioral substrates with emphasis on personality, emotions, nervous system, stress, behavioral correlates of disease, communication, and society. Prerequisite: Beh.Sc. 502.

511. Medical Statistics and Research Design (2) Use of theoretical and applied statistics in medical research design and in the interpretation of data.

521. Primate Behavior (3) Monkey to man survey of intelligence, learning, social behavior, emotions growth, and physiology; techniques of primate research.

531. Behavioral and Physiological Correlates of Stress (3) Effects of stress on all physiological processes and role of learning, cognition, personality, and culture in adapting to stress.

535. Nervous Systems and Behavior (3) Synthesis on behavioral science, neurobiology, and physiology with emphasis on integrative functions of peripheral, central, and autonomic nervous systems.

540. Seminar (1-6) Critical discussion of current literature and research within the behavioral sciences, emphasizing research design, methods, interpretation, and synthesis.

551. Health, Illness, and Culture (3) A medical sociology seminar devoted to the socio-cultural aspects of health and sickness.

555. Behavior Change (3) Review of behavioral science research and theory relevant for behavior change procedures used in medicine.

570. Special Topics (1-6) Original and current literature and research methods in special areas in the behavioral sciences.

590. Research Problems (3-12) Independent work to develop and test creative and original hypotheses.

BIOLOGICAL CHEMISTRY (BCHEM)

502. Biological Chemistry (5) Principles of biological chemistry with emphasis on the relationship of macromolecular structure to function in metabolic pathways and specialized tissues.

503. Biological Chemistry of Nucleic Acids (2) Detailed discussion of nucleic

acid biochemistry and its relation to genetic phenomena, especially organization, mutation, and segregation of genetic material.

513. Biological Chemistry Macromolecules (3) Methods of detailed determination of the three-dimensional structure of macromolecules, primarily enzymes and amino acid sequence and conformation of protein.

523. Metabolism (3) Molecular mechanisms employed by living systems to transform biological compounds, control production and utilization of energy, and regulate metabolic pathways.

540. Seminar (1 per term) Critical discussion of current literature within a facet of biochemistry; experimental design, procedures, and interpretation of results to be emphasized.

570. Special Topics (2) Discrete areas of contemporary research in conformational analysis and natural product structure, complex polysaccharide structure, neurochemistry, and biochemistry of disease.

590. Research Problems (1-12) Individualized research on biochemical problems conducted by students in departmental laboratories.

FAMILY AND COMMUNITY MEDICINE (FCMED)

501. Family and Community Medicine (1) An intimate view of continuing comprehensive medical care of each person in a family in the community setting.

510. Normal Sexual Development (1) The basis, development, and pattern of normal sexual development, with an emphasis on the range of "normal."

515. Economics of Health Care (1) Health costs and various means of meeting them.

521, 522, 523. Family and Community Medicine (2,2,1) Introduction to preventive and community medicine; further development of the principles of physician-patient responsibility.

525. Emergency Room Medicine (2) Principles of emergency care as practiced in the hospital emergency room and on ambulance calls.

526. First Aid (1) Principles of first aid with practice under supervision.

HUMANITIES (HUMAN)

501. Human Values in Medical Care (2) Analysis of questions, concepts, and ramifications of moral and religious values of health and illness; principles of professional responsibility.

505. Ethics and Human Experimentation (2) An analysis of the ethical, moral, and legal aspects of clinical investigation in medicine.

511. Humanities (2) Selected issues in the history and philosophy of science and their relation to culture.

521. Philosophical Ethics (2) A critical delineation and examination of the conceptual framework of ethics.

525. Philosophy of Science (2) An introduction to the basic concepts of the philosophy of science.

541. Science and American Democracy (2) The development of the sciences and institutions of scientific endeavor from colonial times to the modern era.

570. Special Topics (1-6) Specialized study of selected topics in the humanities.

LABORATORY ANIMAL MEDICINE (L A M)

501. Biology and Care of Laboratory Animals (2) Presentation of the anatomic and physiologic characteristics of the commonly used laboratory animal species and their relation to biomedical research.

503. Laboratory Animal Genetics (2) Genetic principles applied to laboratory animals used for investigations of diseases that may be controlled or influenced by genetic factors.

505. Laboratory Animal Zoonoses (2) Experimentally induced, spontaneous, and infectious diseases transmissible between man and animals with special emphasis on etiology, differential diagnosis, and control.

507. Techniques of Laboratory Animal Experimentation (2) Techniques of drug administration, infusion, and collection of body fluids and materials; gnotobiology; use of radioisotopes and bioinstrumentation.

510. Animal Physiological Surgery (2) Selected operative procedures, demonstrating principles of physiology with modern biomedical instrumentation, will be followed through the postoperative period.

515. Experimental Surgery of Laboratory Animals (3) Surgical techniques, including nephrectomy and Goldblatt clamp, bladder and gastric pouches, bile duct connulation, intraventricular operation, cardiac and cerebrovascular catherization.

530. Disease of Laboratory Animals, I (3) Physiological and pathological expressions of both infectious and metabolic-degenerative disease of rodents, with emphasis on diagnostic and control methods.

531. Diseases of Laboratory Animals, II (3) Physiological and pathological expressions of both infectious and metabolic-degenerative disease of nonhuman primates and other species of animals.

535. Comparative Pathology of Laboratory Animals (3) Comparative pathologic characteristics of infectious and metabolic disease of animals and man.

540. Seminar (1 per term) Student and faculty discussions of organization and presentation of data on recent advances in selected topics of laboratory animal medicine.

570. Special Topics (1-6) Specialized training in advanced research techniques and current status of research in the various areas of laboratory animal medicine.

590. Research Problems (1-12) Research training will be given to enable the student to advance his knowledge about some aspect of laboratory animal medicine.

MICROBIOLOGY (MICRB)

551. Medical Microbiology (3) Principles of microbiology; viruses, rickettsia, bacteria, and fungi as agents of disease. Introduction of microbial genetics, epidemiology, and immune mechanisms.

552. Medical Microbiology Laboratory (2) Laboratory exercises to augment Micrb. 551. Laboratory tests used to characterize microorganisms and to aid in diagnosis of disease.

553. Science of Virology (3) Replication of viruses and effect on host, including transfer of genetic information, immunology, and oncogenic properties of viruses.

554. Immunology of Infection (3) The nature of antigens and antibodies, humoral and cellular immune response governing histocompatability, transplantation, tolerance, and auto-immune disease.

555. Microbial Physiology and Metabolism (3) Physiology and comparative biochemistry of microorganisms, especially human pathogens. Concepts of genetic regulation and balanced growth applied to cell replication.

556. Microbial Genetics (3) Genetics of microorganisms, including gene mapping, lysogeny, information transfer, and viral carcinogenesis.

570. Topics in Microbiology (1 per term) Lectures and seminars concerning current developments in microbiology.

571. Seminar in Microbiology (1 per term) Weekly presentation by faculty and postdoctoral and predoctoral trainees of current work in the department.

572. Literature Reports (1 per term) Weekly analysis of current literature in microbiology.

573. Selected Readings (2 per term; maximum of 6 per student) Supervised reading program of pertinent literature in microbiology and related scientific fields.

580. Laboratory Experiments in Microbiology (2-6 per term) Laboratory exercises in microbiology, including cell culture, microscopy, radioisotope and other biochemical procedures, serology, and genetic techniques.

581. Special Projects in Microbiology (2-6 per term) Research projects carried out by graduate students under supervision of a member of the faculty.

PATHOLOGY (PATH)

501. Principles of Pathology (4) The fundamentals of reaction to injury at cellular and tissue levels emphasizing the pathogenesis of functional, structural, and biochemical abnormalities. Prerequisite: admission to College of Medicine.

502. Principles of Pathology (4) The fundamentals of human disease with emphasis on pathogenesis of functional, structural, and biochemical abnormalities at the organ system level. Prerequisite: admission to College of Medicine.

510. The Clinical Laboratory in Laboratory Medicine (5) Seminars, tutorials, and independent analysis by the student of specific laboratory problems which relate to human disease. Prerequisites: admission to College of Medicine; Path. 501, 502.

513. Applied Surgical Pathology (4) Students will study tissues daily received by the surgical pathology laboratory. Problems encountered in many clinical specialties will be considered. Prerequisites: admission to College of Medicine; Path. 501, 502.

516. Autopsy Pathology (5) Students will first assist and then perform autopsies under supervision. Emphasis will be on correlations with clinical and experimental medicine. Prerequisites: admission to College of Medicine; Path. 501, 502.

520. Biology of Neoplasia (3) Detailed examination of the initiation and pathogenesis of animal neoplasms with emphasis on the relationship to human neoplasia. Prerequisite: admission to College of Medicine.

524. Biological Membranes, Structure and Function (2) Critical consideration of biological membranes emphasizing comparative structure and biochemical composition through small group discussion and review of current literature. Prerequisite: admission to College of Medicine.

530. Tropical Pathology (4) Study of diseases commonly encountered in tropical areas with emphasis on parasites and infectious and nutritional disorders. Prerequisite: admission to College of Medicine; Path. 501, 502.

540. Development of Educational Tools and Methods in Pathology (3) Development of new educational tools and methods to teach pathogenesis of disease to patients, medical students, and medical technology students. Prerequisite: admission to the College of Medicine.

560. Pathology Seminar (1) Staff and student seminar covers current research and educational and service developments in the field. Prerequisite: admission to College of Medicine.

570. Special Topics in Pathology (1-6) Specialized training in advanced research techniques available in the department. Prerequisite: admission to College of Medicine.

590. Research Problems in Pathology (1-12) Individualized research on patheology problems conducted by students in medical school laboratories. Prerequisite: admission to College of Medicine.

PHARMACOLOGY (PHARM)

501. Pharmacology (3) Lectures, discussions, and laboratory study of the mechanism of drug action in biological systems.

502. Pharmacology (4) Continuation of Pharm. 501.

504. Drug Metabolism (3) Study of chemical transformation of drugs within animal cells and drug metabolizing enzymes present in liver microsomes performing this function. Prerequisite: Pharm. 501.

506. Pharmacology of Endocrine Organs (3) Current concepts of interaction of endocrine tissue with endogenous compounds and pharmacological agents. Prerequisite: Pharm. 501.

507. Pharmacology of Psychoactive Drugs (3) Current theories of mental diseases and pharmacological agents used to treat them will be covered. Prerequisite: Pharm. 501.

508. Pharmacology of Biologically Active Monamines (3) The role of monamines in body function and alteration of their activity by drugs will be discussed. Prerequisite: Pharm. 501.

509. Development of Therapeutic Agents (3) This course will deal with stages of drug development ranging from laboratory studies to routine human consumption.

515. Human Genetics (2) Seminar-type presentations by students and staff on fundamental problems and current topics in human genetics.

540. Pharmacogenetics (3) Study of human responses to individual drugs.

550. Autonomic Nervous System Pharmacology (3) Study of drugs concerned with and acting on the sympathetic and parasympathetic nervous systems.

560. Pharmacology Seminar (1) Student and staff seminar designed to familiarize medical and graduate students with current research developments in the field.

570. Special Topics (1-6) Introduction of students to the research laboratory and the scholarly pursuits of members of the staff.

590. Research (1-12) Individualized research conducted by students in departmental laboratories.

PHYSIOLOGY (PHSIO)

520. Medical Physiology (2) Cellular physiology including membrane permeability, bioelectric potentials, muscle contractions, secretion; cardiovascular physiology including hemodynamics, cardiac function and output, peripheral circulations.

521. Medical Physiology (4) Organ and metabolic physiology, including renal, endocrine, neuromuscular, gastrointestinal, and respiratory.

525. General Physiology (2) Cellular processes of accumulation membrane transport, bioelectric potentials, contraction, and secretion in erythrocytes, nerves, sensory receptors, muscles, glands, excretory organs.

530. Metabolic and Endocrine Physiology (3) Regulation of carbohydrates, fatty acid and protein metabolism; regulation of hormone secretion; effects of hormones on water and cell metabolism.

550. Seminar (1 per term) Critical appraisal by staff and students of current research developments and of data collected in current investigations.

570. Special Topics (1-6) Training in the use of research techniques; examination in depth of a specialized topic on the level of current research.

590. Research Problems (1-12) Individualized research conducted by students in departmental laboratories.

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1971-1972

The Pennsylvania State University Bulletin

Graduate Degree Programs

1971-1972

THE PENNSYLVANIA STATE UNIVERSITY

GRADUATE DEGREE PROGRAMS

GENERAL CATALOG ISSUE

SEPTEMBER 1971

GRADUATE CALENDAR*

SUMMER TERM 1971

MAY 1971

29 Saturday—Last Date for a Prospective Graduate Student to Submit Completed Application Materials for Admission to the Summer Term 1971

29 Saturday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Summer Term 1971

JUNE

29, 30 Tuesday and Wednesday—Pre-examinations in German for Advanced Degree Candidates

29, 30 Tuesday (P.M.) and Wednesday—Summer Term Registration

JULY

1 Thursday—Summer Term Classes Begin 8:00 A.M.

5 Monday—Independence Day Holiday

9 Friday—Last Date for Registering with Foreign Language Departments (Other than French and Spanish) for Written Language Examinations

16 Friday—Last Date for Registering with French and Spanish Departments for Written Language Examinations

19 Monday—Last Date for a September Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office

22 Thursday—Last Date for a September Graduate to Deliver Doctoral Thesis to Committee

24 Saturday—Written French and Spanish Language Examinations for Advanced Degree Candidates

27 Tuesday—Last Date for Written Foreign Language Examinations (Other than French and Spanish) for Advanced Degree Candidates

29 Thursday—Last Date for Final Oral Doctoral Examination for September Graduates

29 Thursday—Last Date for a September Graduate to Deliver Master's Thesis or Paper to Adviser

AUGUST

9 Monday—Last Date for a September Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Completion of Required Papers

9 Monday—Last Date for a September Graduate to Order Cap, Gown, and Hood Locally

26 Thursday—Eight-Week Summer Term Classes End 9:55 P.M.

SEPTEMBER

2 Thursday—Last Date for Submitting a Petition to Graduate in Absentia in September

6 Monday—Labor Day Holiday

10 Friday—Ten-Week Summer Term Classes End 9:55 P.M.

11, 13 Saturday and Monday—Final Examinations

16 Thursday—Commencement

* This calendar was approved on May 1, 1971, and is subject to change without notice. In preparing the calendar for an academic year, the University makes every effort to avoid conflicts with religious holidays. However, such conflicts are sometimes unavoidable. When they occur, efforts are made to make special arrangements for the students affected.

FALL TERM 1971

AUGUST 1971

23 Monday—Last Date for a Prospective Graduate Student to Submit Completed Application Materials for Admission to the Fall Term 1971

23 Monday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Fall Term 1971

SEPTEMBER

22-24 Wednesday to Friday—Pre-examinations in German for Advanced Degree Candidates

22-24 Wednesday to Friday—Fall Term Registration

27 Monday—Fall Term Classes Begin 8:00 A.M.

OCTOBER

1 Friday—Last Date for Registering with French and Spanish Departments for Written Language Examinations

4 Monday—Last Date for Registering with Foreign Language Departments (Other than French and Spanish) for Written Language Examinations

9 Saturday—Written French and Spanish Language Examinations for Advanced Degree Candidates

14 Thursday—Last Date for a December Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office

19 Tuesday—Last Date for Written Foreign Language Examinations (Other than French and Spanish) for Advanced Degree Candidates

23 Saturday—Last Date for a December Graduate to Deliver Doctoral Thesis to Committee

30 Saturday—Last Date for Final Oral Doctoral Examination for December Graduates

30 Saturday—Last Date for a December Graduate to Deliver Master's Thesis or Paper to Adviser

NOVEMBER

15 Monday—Last Date for a December Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Completion of Required Papers

15 Monday—Last Date for a December Graduate to Order Cap, Gown, and Hood Locally

24-28 Wednesday 12:25 P.M. to Monday 8:00 A.M.—Thanksgiving Recess

DECEMBER

4 Saturday—Last Date for Submitting a Petition to Graduate in Absentia in December

8 Wednesday—Fall Term Classes End 9:55 P.M.

9 Thursday—Study Day

10-14 Friday to Tuesday—Final Examinations

18 Saturday—Commencement

WINTER TERM 1972

DECEMBER 1971

4 Saturday—Last Date for a Prospective Graduate Student to Submit Completed Application Materials for Admission to the Winter Term 1972

4 Saturday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Winter Term 1972

JANUARY 1972

4, 5 Tuesday and Wednesday—Pre-examinations in German for Advanced Degree Candidates

4, 5 Tuesday and Wednesday—Winter Term Registration (essential changes only)
6 Thursday—Winter Term Classes Begin 8:00 A.M.
14 Friday—Last Date for Registering with Foreign Language Departments (Other than French and Spanish) for Written Language Examinations
24 Monday—Last Date for a March Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office
28 Friday—Last Date for Registering with French and Spanish Departments for Written Language Examinations
29 Saturday—Last Date for a March Graduate to Deliver Doctoral Thesis to Committee

FEBRUARY

1 Tuesday—Last Date for Written Foreign Language Examinations (Other than French and Spanish) for Advanced Degree Candidates
5 Saturday—Written French and Spanish Language Examinations for Advanced Degree Candidates
5 Saturday—Last Date for Final Oral Doctoral Examination for March Graduates
5 Saturday—Last Date for a March Graduate to Deliver Master's Thesis or Paper to Adviser
21 Monday—Last Date for a March Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Completion of Required Papers
21 Monday—Last Date for a March Graduate to Order Cap, Gown, and Hood Locally

MARCH

11 Saturday A.M.—Last Date for Submitting a Petition to Graduate in Absentia in March
15 Wednesday—Winter Term Classes End 9:55 P.M.
16 Thursday—Study Day
17-21 Friday to Tuesday—Final Examinations
25 Saturday—Commencement

SPRING TERM 1972

MARCH 1972

4 Saturday—Last Date for a Prospective Graduate Student to Submit Completed Application Materials for Admission to the Spring Term 1972
4 Saturday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Spring Term 1972

APRIL

4, 5 Tuesday and Wednesday—Pre-examinations in German for Advanced Degree Candidates
4, 5 Tuesday and Wednesday—Spring Term Registration (essential changes only)
6 Thursday—Spring Term Classes Begin 8:00 A.M.
7 Friday—Last Date for Registering with French and Spanish Departments for Written Language Examinations
14 Friday—Last Date for Registering with Foreign Language Departments (Other than French and Spanish) for Written Language Examinations
15 Saturday—Written French and Spanish Language Examinations for Advanced Degree Candidates
24 Monday—Last Date for a June Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office
29 Saturday—Last Date for a June Graduate to Deliver Doctoral Thesis to Committee

MAY

2 Tuesday—Last Date for Written Foreign Language Examinations (Other than French and Spanish) for Advanced Degree Candidates

6 Saturday—Last Date for Final Oral Doctoral Examination for June Graduates

6 Saturday—Last Date for a June Graduate to Deliver Master's Thesis or Paper to Adviser

16 Tuesday—Annual Graduate Faculty Meeting

22 Monday—Last Date for a June Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Completion of Required Papers

22 Monday—Last Date for a June Graduate to Order Cap, Gown, and Hood Locally

JUNE

10 Saturday A.M.—Last Date for Submitting a Petition to Graduate in Absentia in June

14 Wednesday—Spring Term Classes End 12:25 P.M.

15-19 Thursday to Monday—Final Examinations

24 Saturday—Commencement

SUMMER TERM 1972

MAY 1972

27 Saturday—Last Date for a Prospective Graduate Student to Submit Completed Application Materials for Admission to the Summer Term 1972

27 Saturday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Summer Term 1972

JUNE

27, 28 Tuesday and Wednesday—Pre-examinations in German for Advanced Degree Candidates

27, 28 Tuesday and Wednesday—Summer Term Registration

29 Thursday—Summer Term Classes Begin 8:00 A.M.

JULY

4 Tuesday—Independence Day Holiday

7 Friday—Last Date for Registering with Foreign Language Departments (Other than French and Spanish) for Written Language Examinations

14 Friday—Last Date for Registering with French and Spanish Departments for Written Language Examinations

17 Monday—Last Date for a September Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office

22 Saturday—Written French and Spanish Language Examinations for Advanced Degree Candidates

22 Saturday—Last Date for a September Graduate to Deliver Doctoral Thesis to Committee

25 Tuesday—Last Date for Written Foreign Language Examinations (Other than French and Spanish) for Advanced Degree Candidates

29 Saturday—Last Date for Final Oral Doctoral Examinations for September Graduates

29 Saturday—Last Date for a September Graduate to Deliver Master's Thesis or Paper to Adviser

AUGUST

14 Monday—Last Date for a September Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Completion of Required Papers

14 Monday—Last Date for a September Graduate to Order Cap, Gown, and Hood Locally
24 Thursday—Eight-Week Summer Term Classes End 9:55 P.M.

SEPTEMBER
2 Saturday A.M.—Last Date for Submitting a Petition to Graduate in Absentia in September
4 Monday—Labor Day Holiday
8 Friday—Ten-Week Summer Term Classes End 9:55 P.M.
11, 12 Monday and Tuesday—Final Examinations
16 Saturday—Commencement

FALL TERM 1972

AUGUST
21 Monday—Last Date for a Prospective Graduate Student to Submit Completed Application Materials for Admission to the Fall Term 1972
21 Monday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Fall Term 1972

SEPTEMBER
20-22 Wednesday to Friday—Pre-examinations in German for Advanced Degree Candidates
20-22 Wednesday to Friday—Fall Term Registration
25 Monday—Fall Term Classes Begin 8:00 A.M.
29 Friday—Last Date for Registering with Foreign Language Departments (Other than French and Spanish) for Written Language Examinations

OCTOBER
6 Friday—Last Date for Registering with French and Spanish Departments for Written Language Examinations
12 Thursday—Last Date for a December Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office
14 Saturday—Written French and Spanish Language Examinations for Advanced Degree Candidates
17 Tuesday—Last Date for Written Foreign Language Examinations (Other than French and Spanish) for Advanced Degree Candidates
21 Saturday—Last Date for a December Graduate to Deliver Doctoral Thesis to Committee
28 Saturday—Last Date for Final Oral Doctoral Examination for December Graduates
28 Saturday—Last Date for a December Graduate to Deliver Master's Thesis or Paper to Adviser

NOVEMBER
13 Monday—Last Date for a December Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Completion of Required Papers
13 Monday—Last Date for a December Graduate to Order Cap, Gown, and Hood Locally
22-27 Wednesday 12:25 P.M. to Monday 8:00 A.M. —Thanksgiving Day Holiday

DECEMBER
2 Saturday A.M.—Last Date for Submitting a Petition to Graduate in Absentia in December
6 Wednesday—Fall Term Classes End 9:55 P.M.
7-11 Thursday to Monday—Final Examinations
16 Saturday—Commencement

WINTER TERM 1973

DECEMBER 1972

4 Monday—Last Date for a Prospective Graduate Student to Submit Completed Application Materials

4 Monday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Winter Term 1973

JANUARY 1973

4, 5 Thursday and Friday—Pre-examinations in German for Advanced Degree Candidates

4, 5 Thursday and Friday—Winter Term Registration

8 Monday—Winter Term Classes Begin 8:00 A.M.

12 Friday—Last Date for Registering with Foreign Language Departments (Other than French and Spanish) for Written Language Examinations

25 Thursday—Last Date for a March Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office

26 Friday—Last Date for Registering with French and Spanish Departments for Written Language Examinations

27 Saturday—Last Date for a March Graduate to Deliver Doctoral Thesis to Committee

30 Tuesday—Last Date for Written Foreign Language Examinations (Other than French and Spanish) for Advanced Degree Candidates

FEBRUARY

3 Saturday—Written French and Spanish Language Examinations for Advanced Degree Candidates

3 Saturday—Last Date for Final Oral Doctoral Examination for March Graduates

3 Saturday—Last Date for a March Graduate to Deliver Master's Thesis or Paper to Adviser

19 Monday—Last Date for a March Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Completion of Required Papers

19 Monday—Last Date for a March Graduate to Order Cap, Gown, and Hood Locally

MARCH

10 Saturday A.M.—Last Date for Submitting a Petition to Graduate in Absentia in March

17 Saturday—Winter Term Classes End 12:25 P.M.

19-22 Monday to Thursday—Final Examinations

24 Saturday—Commencement

SPRING TERM 1973

FEBRUARY 1973

24 Saturday—Last Date for a Prospective Graduate Student to Submit Completed Application Materials for Admission to the Spring Term 1973

24 Saturday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Spring Term 1973

MARCH

27, 28 Tuesday and Wednesday—Pre-examinations in German for Advanced Degree Candidates

27, 28 Tuesday and Wednesday—Spring Term Registration

29 Thursday—Spring Term Classes Begin 8:00 A.M.

APRIL

6 Friday—Last Date for Registering with Foreign Language Departments (Other than French and Spanish) for Written Language Examinations

6 Friday—Last Date for Registering with French and Spanish Departments for Written Language Examinations

14 Saturday—Written French and Spanish Language Examinations for Advanced Degree Candidates

16 Monday—Last Date for a June Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office

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28 Saturday—Last Date for a June Graduate to Deliver Master's Thesis or Paper to Adviser

MAY

14 Monday—Last Date for a June Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Completion of Required Papers

14 Monday—Last Date for a June Graduate to Order Cap, Gown, and Hood Locally

15 Tuesday—Annual Graduate Faculty Meeting

JUNE

2 Saturday A.M.—Last Date for Submitting a Petition to Graduate in Absentia in June

6 Wednesday—Spring Term Classes End 9:55 P.M.

7-11 Thursday to Monday—Final Examinations

16 Saturday—Commencement

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Joanne Z. Feldman, M.S. (Juilliard) — *Assistant Professor of Music*
Leonard Feldman, M.Mus. (Eastman) — *Associate Professor of Music*
Burt L. Fenner, M.A. (Columbia) — *Assistant Professor of Music*
Ronald L. Filippelli, Ph.D. (Penn State) — *Historical Collections Archivist*
Charles H. Firmin, M.F.A. (Penn State) — *Instructor in Theatre Arts*
Charles Forney, Jr., M.S. (Penn State) — *Assistant Professor of Computer Science*
James J. Gebhard, Ph.D. (Indiana) — *Instructor in Slavic Languages*
Anne A. Gibson, M.F.A. (Carnegie-Mellon) — *Assistant Professor of Theatre Arts*
Trond Gilberg, Ph.D. (Wisconsin) — *Assistant Professor of Political Science*
Stella R. Goldberg, Ed.D. (Columbia) — *Assoc. Prof. of Child Dev. and Family Rel.*
Steven L. Goldman, Ph.D. (Boston) — *Assistant Professor of Philosophy*
Jon P. Gunnemann, M.A. (Yale) — *Assistant Professor of Religious Studies*
Dorothy V. Harris, Ph.D. (Iowa) — *Associate Professor of Physical Education*
Gerard A. Hauser, Ph.D. (Wisconsin) — *Assistant Professor of Speech*
Carol Hendrick, M.M. (Yale) — *Instructor in Music*
Donald E. Hopkins, M.Mus. (Texas) — *Assistant Professor of Music*
Robert E. Huff, Ph.D. (North Carolina) — *Assistant Professor of Mathematics*
Mary Jedele, M.M. (Eastman) — *Assistant Professor of Music*
Barton L. Jenks, Jr., M.S. (Princeton) P.E. — *Assoc. Prof. of Mechanical Eng.*
Ronald W. Johnson, M.A. (S.U.N.Y.) — *Asst. Prof. of Public Admin. & Pol. Sci.*
Donald B. Keat II, Ph.D. (Temple) — *Assistant Professor of Education*
Wells H. Keddie, Ph.D. (Claremont) — *Assistant Professor of Labor Studies*
Manfred E. Keune, Ph.D. (Michigan State) — *Assistant Professor of German*
Oscar A. Kimmel, M.S. (Penn State) — *Associate Professor of Farm Mechanics*
Lawrence A. Klimko, Ph.D. (Ohio State) — *Assistant Professor of Mathematics*
Edgar H. Knapp, Ed.D. (Columbia) — *Associate Professor of English and Education*
William J. Knight, Ph.D. (California) — *Assistant Professor of Mathematics*
Alfred E. Kohout, M.F.A. (Wisconsin) — *Assistant Professor of Theatre Arts*
Glorianne M. Leck, Ph.D. (Wisconsin) — *Assistant Professor of Education*
Richard E. Llorens, Ph.D. (Penn State) — *Assoc. Prof. of Engineering Mechanics*
Ernest B. Lowrie, M.A. (Yale) — *Assistant Professor of Religious Studies*
Thomas D. Marro, D.Ed. (Colorado State) — *Asst. Prof. of Special Education*
Javier Martinez-Palacio, B.A. (Sagrada Familia Lic. en Derecho) — *Assistant Professor of Spanish*
Albert K. Mastantuono, Ph.D. (Western Reserve) — *Asst. Prof. of Special Ed.*
Peter B. Meyer, Ph.D. (Wisconsin) — *Asst. Prof. of Economic Planning*
D. Douglas Miller, M.M. (Drake) — *Assistant Professor of Music*
P. June Miller, M.Mus. (Yale) — *Assistant Professor of Music*
Webb C. Miller, Ph.D. (Washington) — *Asst. Prof. of Computer Science*
Frank L. Moreland, Ph.D. (California) — *Asst. Prof. of Environmental Planning*
James L. Morrison, Ph.D. (Florida State) — *Asst. Prof. of Ed. and Sociology*
Ursula Mueller, Ph.D. (Frankfurt) — *Assistant Professor of Mathematics*
Raymond O. Murphy, D.Ed. (Penn State) — *Assistant Professor of Education*
M. Eloise Murray, Ph.D. (Penn State) — *Asst. Prof. of Home Economics Ed.*
Joan Nessler, Ph.D. (Penn State) — *Associate Professor of Physical Education*
William G. Noyes, M.Ed. (Penn State) — *Assistant Professor of Music*
Charles P. Orlando, Ph.D. (Connecticut) — *Asst. Prof. of Special Ed.*
H. Raymond Page, M.A. (Ohio State) — *Assistant Professor of Music*
Torrence D. Parsons, Ph.D. (Princeton) — *Assistant Professor of Mathematics*

James H. Patterson, Q.B.A. (Indiana) — *Asst. Prof. of Management Science*
Harry Perison, M.M. (Eastman) — *Assistant Professor of Music*
Dan J. Peterman, Ph.D. (California) — *Asst. Prof. of Human Development*
Marian A. Quick, M.A. (Smith) — *Associate Professor of Deaf Education*
Carl A. Ridley, Jr., Ph.D. (Florida State) — *Asst. Prof. of Human Development*
Gerald G. Robine, M.Ed. (Penn State) — *Instructor in Special Education*
Audrey T. Rodgers, Ph.D. (Penn State) — *Assistant Professor of English*
Dante V. Scalzi, D.Ed. (Penn State) — *Assistant Professor of Education*
Robert J. Scannell, Ph.D. (Penn State) — *Professor of Physical Education*
Joel E. Schneider, Ph.D. (Oregon) — *Assistant Professor of Mathematics*
William T. M. Seebohm, Dr.phil. habil. (Universitat Mainz) — *Visiting Associate Professor of Philosophy*
Gordon M. Shedd, Ph.D. (Penn State) — *Assistant Professor of English*
Jane M. Singh, Ed.D. (Arizona State) — *Assistant Professor of Education*
A. K. Sinha, Ph.D. (Sheffield) — *Assistant Professor of Mining*
Ronald A. Smith, Ph.D. (Wisconsin) — *Asst. Prof. of Physical Education*
Lloyd M. Sundblad, Ph.D. (Syracuse) — *Assistant Professor of Education*
Smith C. Toulson III, M.M. (Yale) — *Assistant Professor of Music*
Robert F. Trehy, Diploma (American Theater) — *Associate Professor of Music*
W. Bruce Trinkley, M.A. (Columbia) — *Instructor in Music*
Richard D. Twark, Ph.D. (Penn State) — *Lecturer in Quantitative Business Analysis*
John D. Walmer, M.D. (Temple) — *Adjunct Associate Professor of Education*
Joseph Warren, Ph.D. (Wayne State) — *Assistant Professor of Mathematics*
Susan F. Weis, Ph.D. (Penn State) — *Asst. Prof. of Home Economics Education*
Charles C. Werberig, M.S. (Syracuse) — *Assistant Professor of Theatre Arts*
Joseph A. Wigley, Ph.D. (Northwestern) — *Associate Professor of Speech*

GENERAL INFORMATION

GRADUATE WORK at The Pennsylvania State University began in 1862 with two graduate students in residence. Two years later a "course for Graduates," which led to the degree of Master of Scientific Agriculture, was formally established, but for a number of years growth was slow and graduate instruction relatively unorganized. Eventually a committee of the University Senate was given the responsibility of guiding graduate study. Standards were established, and regulations were set up to govern the conferring of master's degrees and certain technical degrees. In 1922 the Graduate School was organized, and the Graduate Faculty was formed. The University Senate (established in 1921) delegated to this faculty responsibility for graduate affairs subject to review. In 1924 the Board of Trustees authorized the granting of the degree of Doctor of Philosophy. On May 9, 1971, a new representative form of governance, as set forth in the "Articles of Authority," under a Graduate Council was established for the Graduate School.

Today graduate study is offered in 124 major fields, with fourteen advanced academic and professional degrees being conferred. During the academic year 1969-70, 4,500-5,000 graduate students were enrolled each term, and 1,600 advanced degrees were conferred, of which 379 were doctorates. The faculty of the Graduate School, numbering about 1,400, controls all academic matters pertaining to the School, subject to review by the University Faculty Senate.

THE GRADUATE SCHOOL—The nature and functions of the Graduate School are different from those of the colleges of the University. Each college is responsible for providing all study and research programs appropriate to its fields. The budgets of the colleges provide for all teaching and research staff and facilities. The Graduate School is not organized around a limited subject matter area. It does not itself offer courses or conduct research in the usual sense, although research in administrative matters is carried on. It has no budgeted faculty; rather, its faculty consists of those members of the college faculties who are evaluated and recommended to the Dean of the Graduate School for appointment to the Graduate Faculty. These faculties offer courses and seminars and supervise thesis research at the graduate level. The Graduate School may, therefore, be regarded as a federation of selected segments of the college faculties.

The governance of the Graduate School is vested in a Graduate Council whose legislative authority is subject to the specific restrictions of the Articles of Authority. The Council consists of approximately forty Graduate Faculty members (associate or senior) elected by voting units from the colleges of the University in which graduate programs are offered, as well as the Graduate Centers at Capitol Campus and King of Prussia. Each member serves for a term of two years. Other voting members of the Council are the Dean of the Graduate School (*ex officio*), a member of the Council of the University Faculty Senate designated by that body, and five graduate students elected through the Graduate Student Association to serve for one year. Officers of the Council are the Dean of the Graduate School, who serves as chairman, and a secretary appointed by the chairman. The Council forms its own committee structure.

Executive and administrative matters of the Graduate School are the responsibility of the Dean, who is charged directly with enforcement of the regulations of the Graduate School and with organization of its administrative procedures. The Graduate School, through the Dean, has a primary responsibility to enhance and insure the high quality of graduate study and research of graduate students on those Campuses of the University where such graduate work is conducted and to provide leadership in initiating new programs and in restructuring of phasing out of marginal and obsolete ones. The Dean encourages and assists development of multidisciplinary programs needed to accommodate the growth of knowledge and the emergence of significant new areas for the application of knowledge. He advises the President of the University on the programs and requirements involved. The Dean is assisted in this work by an administrative and clerical staff.

GRADUATE CENTERS

There are four major administrative divisions in the Graduate School which may be contacted directly for answers to the many questions which are directed to the administrative center:

Graduate Admissions—Director of Admissions Bernard J. Busovne
308 Graduate Building, University Park, Pa. 16802
Telephone (814) 865-1795

Admission is granted jointly by the Graduate School and the department in which the student plans to follow his studies. The establishment of standards by which applicants are accepted is a departmental responsibility. Graduate Admission has the responsibility for processing all matters pertaining to a student's admission. For detailed information see "Admission," page 41 of this bulletin.

Graduate Student Programs—Associate Dean Ernest H. Ludwig
211 Graduate Building, University Park, Pa. 16802
Telephone (814) 865-1834

The functions of this office include: (1) registration of students, (2) readmission of students, (3) maintenance of records, (4) appointment of graduate committees for doctoral students, (5) scheduling of graduate student comprehensive examinations and defense of thesis and monitoring the results of these examinations, (6) checking for accomplishment by students of Graduate Faculty requirements for all advanced degrees and preparation of official commencement lists, and (7) attention to student academic problems.

Graduate Fellowships—Assistant Dean Benjamin F. Howell, Jr.
317 Graduate Building, University Park, Pa. 16802
Telephone (814) 865-2514

The work of the Office of Graduate Fellowships falls into three principal categories (1) to serve as a clearing house on information on available fellowships and other awards for graduate students, (2) to administer fellowship and other award programs involving students in more than one College, and (3) to seek support for graduate students attending the University.

Theses and Publications—Editorial Assistant Una M. Livingston
320 Graduate Building, University Park, Pa. 16802
Telephone (814) 865-5448

This office functions (1) to coordinate and supervise within Graduate School structure and policy all duties pertaining to thesis acceptance and editorial review of format consistent with the attainment of the highest scholarly goals, and (2) to provide source materials through the publication of eight major Graduate School publications.

Graduate Commons—The Graduate Commons, located on the first floor of the Graduate Building, provides facilities for the Graduate School community and a common meeting ground for faculty and students for formal and informal discussions. The Office of the Manager, J. W. Johnston, serves as a clearing house for the scheduling of events planned by organizations and individuals. An advisory committee of five Graduate Faculty members and five graduate students establishes policy and formulates programs.

Limited cafeteria service is available in the Graduate Commons from 7:30 A.M. through the early evening hours Monday through Friday.

GRADUATE CENTERS—University Graduate Centers have been established in the Erie, Philadelphia, and Harrisburg areas. They operate under the immediate direction of a resident representative of the Graduate School and have full-time resident faculty members as well as part-time staff. Programs to be offered in a Center will depend upon its location, the degree of interest, and the availability of qualified students in the immediate area.

Interested students may write directly to the Dean at the Center for information on programs and courses. Addresses are given on page 2.

Behrend Graduate Center—The Behrend Graduate Center at Erie opened with the winter term, January 1969, and provides convenient opportunity for graduate education to persons residing in northwestern Pennsylvania. It has been established to offer individual courses and a program leading to the degree of Master of Engineering with a major in engineering science.

King of Prussia Graduate Center—The King of Prussia Graduate Center near Philadelphia opened in 1963. Its programs lead to the degree of Master of Engineering with a major in engineering science and Master of Education with a major in mathematics.

The Capitol Campus—The Capitol Campus, located near Middletown and named for its proximity to the State Capitol, was opened in 1966. Graduate programs leading to the degrees of Master of Administration, Master of Arts with a major in humanities, Master of Education with a major in elementary education, Master of Engineering with a major in engineering science, and Master of Regional Planning are currently offered; others are in the planning stage. Further details about the graduate programs and courses are given in *The Capitol Campus Catalog,* obtainable from the Office of Admissions, The Capitol Campus, Middletown, Pa. 17057.

The Milton S. Hershey Medical Center—The University's Medical Center was established in 1963, and the first class of medical students entered in the fall of 1967. The Center is located in Hershey, Pennsylvania, twelve miles from Harrisburg, and all teaching and research facilities at the Campus are new. The Medical Sciences Building and the Animal Research Farm are completed; a 350-bed Teaching Hospital, built as a continuous unit with the Medical Sciences Building, was completed in the winter of 1971.

In conjunction with The Pennsylvania State University's Graduate School, the College of Medicine offers programs leading to the M.S. degree with a major in laboratory animal medicine, and to the M.S. and Ph.D. degrees with majors in anatomy, biological chemistry, microbiology, pharmacology, and physiology. Postdoctoral fellows are in residence in all the basic sciences. Additional information about the graduate programs and course descriptions at the Medical Center can be found in The Milton S. Hershey Medical Center catalog. Copies of the catalog may be obtained by contacting the Dean of the College, The Milton S. Hershey Medical Center, 500 Hershey Drive, Hershey, Pa. 17033.

COOPERATIVE ARRANGEMENTS WITH OTHER INSTITUTIONS—A working arrangement has been established with Jefferson Medical College of Philadelphia whereby a candidate for an advanced degree at Jefferson may do part of his graduate work at Penn State by scheduling relevant courses and research at University Park. Similarly, a graduate student with an appropriate major at Penn State may earn credits at Jefferson which, upon advance approval by his major department, will be accepted in partial fulfillment of degree requirements at Penn State.

UNIVERSITY LIBRARIES—The libraries at University Park include a central collection and two special libraries (serving the Colleges of Agriculture and Arts and Architecture) in the Fred Lewis Pattee Library; four separate branch libraries serving the Colleges of Earth and Mineral Sciences, Engineering, Human Development, and Science; and two reading rooms for the Departments of Architecture and Mathematics. They contain approximately 1,100,000 catalogued volumes, some 583,000 government documents, and more than 1,000,000 other bibliographical items (microforms, maps, manuscripts, etc.).

The central collection includes reference materials in the humanities and social sciences, books, periodicals, newspapers, and microforms in the fields of agriculture, biology, education and psychology, economics and business, the fine arts and humanities, and the natural and social sciences. It also includes maps, documents, and manuscripts and among its special collections are those on Penn State, the history of Pennsylvania, Joseph Priestly, labor history, Utopian fiction, the Renaissance, Aus-

tralian art and literature, American gift books and manuals and rare books. A collection of spoken word records is also available. The branch libraries and reading rooms contain books and journals needed for the subjects studied in those colleges and departments. A number of instructional guides to assist faculty and students in using the facilities are issued by the libraries and may be obtained at service desks. Included among the special resource guides issued by the library is *Newspapers in Microform.*

The University Libraries belong to several cooperative networks. These include Mid-Atlantic Research Libraries Information Network, Area College Library Cooperative Program of Central Pennsylvania, and the Pennsylvania Regional Library Resource Program. Through these and other borrowing arrangements, materials not owned by the University Libraries may be obtained for graduate students and faculty.

The hours of the University Libraries during terms are:

Pattee (including Agricultural and Biological Sciences Library, Arts Library, Undergraduate Library)

Monday—Friday	7:45 a.m. to 12:00 midnight
Saturday	7:45 a.m. to 10:00 p.m.
Sunday	1:00 p.m. to 12:00 midnight

Branch Libraries and Mathematics Reading Room

Monday—Friday	7:45 a.m. to 11:00 p.m.
Saturday	7:45 a.m. to 10:00 p.m.
Sunday	1:00 p.m. to 11:00 p.m.

Architectural Reading Room

Monday—Friday	8:00 a.m. to 5:00 p.m., 7:00 p.m. to 10:00 p.m.
Saturday	8:00 a.m. to 5:00 p.m.
Sunday	2:00 p.m. to 5:00 p.m., 7:00 p.m. to 10:00 p.m.

Branch Undergraduate Libraries (East, North, Pollock-South)

Monday—Friday	9:00 a.m. to 12:00 midnight
Saturday	9:00 a.m. to 5:00 p.m.
Sunday	1:00 p.m. to 12:00 midnight

A schedule of hours for summer term and vacation periods is available upon request at the circulation desk in Pattee or at other service points.

COMPUTATION CENTER—The Computation Center was established under the office of the Vice President for Research to aid in the education and research programs of all academic departments. Its facilities are open to graduate students and faculty engaged in research and to students doing class assignments. Its equipment includes two large System/360 computers, an Adage AGT-30, a 1401, and several small peripheral machines. The System/360 Model 67 has one million bytes of fast core storage, two million bytes of slower core storage, 600 million bytes of disk and drum storage, and a large configuration of input/output equipment. Access to the Model 67 can be obtained through high speed batch terminals located on the main campus or through medium speed batch terminals located at the Commonwealth Campuses. The System/360 Model 50 is about one-half the size of the Model 67 and is devoted to time-sharing services. Several access stations, providing instant turnaround for short jobs, are available for students first learning to use a computer. Typewriter terminals may access either the Model 50 APL/360 time-sharing system or the Model 67 remote job entry facility using the dial telephone network. A well-equipped ADAGE AGT/360 Computer Graphics System allows extensive graphics work. An interface to the Model 67 further extends its graphics capability. The Computation Center staff conducts workshops to acquaint graduate students and faculty with its services. A student who will need the Center's facilities should attend these workshops and should consult the staff early in his research so that a program can be worked out for his project and his work scheduled without delay. Programming con-

sultants in the Center provide advice and assistance in using library programs prepared by the Center and in programming and checking out new applications. The facilities of the Computation Center are widely used for instruction and research in most academic departments at no charge to the student.

PROCEDURES AND REGULATIONS

A student is expected to assume full responsibility for knowing the regulations and pertinent procedures of the Graduate School as set forth in the publication, the *Manual for Graduate Students,* and the *Thesis Information Bulletin,* and for meeting the standards and requirements expressed by these regulations. The *Manual,* which is available to a student after he has been admitted, sets forth in more detail the procedures governing registration, changes in program, and graduation, and gives other information about the Graduate School which is useful to graduate students. Every student should secure a copy from the Office of the Dean soon after admission.

ADMISSION

An applicant for admission to the Graduate School should understand that graduate work is not a simple extension of an undergraduate program. It operates at a higher level, demands scholarship of a higher order, and emphasizes research, creativity, and professional competence with a minimum of formal requirements and a maximum of student initiative and responsibility.

Applicants must recognize that staff, facilities, and other resources are limited so that not all qualified persons can be admitted. The number accepted will vary by department and from term to term. In some fields all vacancies will have been filled long before the deadline for submitting applications so that even outstanding students cannot be accepted. The objective of the Graduate School is to admit a graduate student body of high qualifications up to the limit of the University's resources to provide graduate programs of outstanding quality. In general, a student may begin his graduate work in fall, winter, spring, or summer.

Students are normally expected to begin work at the University Park Campus unless they have been admitted to an approved graduate program offered at one of the Graduate Centers. Applications will not be processed for locations other than the University Park Campus and the Graduate Centers. Applicants interested in programs offered at Behrend, Capitol, and King of Prussia Graduate Centers should apply directly to those Centers. Any exception to this policy must be approved jointly by the graduate department and the Office of Graduate Admissions.

For admission to the Graduate School an applicant must have received a baccalaureate degree from an accredited institution, earned under residence and credit conditions substantially equivalent to those required by The Pennsylvania State University. He must ordinarily have completed in a satisfactory manner a certain minimum of course work in designated areas, the specific courses and amount of work depending upon the field of advanced work which the student proposes to enter.

Admission is granted jointly by the Graduate School and the department in which the student plans to follow his studies. The establishment of standards by which applicants are admitted is a departmental responsibility. Though the Graduate School has no fixed minimum grade-point requirement for admission, an applicant is generally expected to maintain during his junior and senior years quality in his work equivalent to a grade-point average of at least 2.50 on The Pennsylvania State University grading scale of A (4) to D (1). Individual departments may establish higher grade-point averages and other criteria by which they will judge candidates

for admission. Departments may also, in exceptional cases, approve admission by reason of special backgrounds, abilities, and interests. Departmental requirements are given in the descriptive statements appearing under the major fields listed in the latter part of this publication.

The above requirements apply particularly to the student who recently completed an undergraduate program and is about to begin graduate study. An applicant who has obtained a graduate degree at a recognized graduate school will be evaluated largely on the basis of the graduate record.

Forms to be used in applying for admission can be obtained from the Office of Graduate Admissions. All academic records, and explanation of the grading system used, should be submitted, in *duplicate*, to the Office of Graduate Admissions, 308 Graduate Building. These must be received from all institutions by the Graduate School at least one month prior to the opening of the term in which he plans to begin his graduate program. Foreign students should plan on applying at least three months prior to the beginning of the term.

The deadline for processing of applications is one month prior to the beginning of a specific term. A complete admissions file which is required for processing an application includes the following items: (1) application blanks, (2) application fee form, (3) a check or money order in the amount of $15.00 made payable to The Pennsylvania State University, and (4) duplicate transcripts from each institution of higher education attended. This applies to the complete academic record, both undergraduate and graduate. If the admissions file is incomplete a month prior to the beginning of the term for which the student has applied, his materials will be processed for the first term following the completion of his admissions file.

A student with a slight deficiency in undergraduate preparation may be admitted and allowed to take a limited number of undergraduate courses to make up the deficiency while proceeding with his graduate program. Courses taken for this purpose do not, of course, apply toward the requirements of the advanced degree.

Admission may be granted to applicants whose credentials are not complete at the time of application because the baccalaureate degree has not yet been conferred, grades for the current term are not yet available, etc. Such admission is subject to cancellation if the complete credentials, on arrival, do not meet the requirements for admission. In the interim, certification of any earned credits will be withheld. If admission should, for any reason, be canceled, the student is thereby automatically dropped from the Graduate School.

A student who plans to take courses for transfer to another institution or to follow a program of study not leading to an advanced degree at this institution should apply for admission as a special nondegree student. The adviser for such a student may be appointed by the department head most closely associated with the student's field of interests. The number of special nondegree students which can be admitted is limited because preference is given to students in degree programs.

A student who has been admitted to a field in which the doctorate is offered may begin working toward that degree, but he has no official status as a doctoral student and no assurance that he will be accepted as a doctoral candidate until he has passed a candidacy examination administered by his major department or committee.

ADVISERS—To assist the student in planning his program, the head of his major department will designate a member of the faculty to serve as adviser. It is the student's responsibility to secure the name of his adviser from the department head and to seek a conference before registration.

ENGLISH PROFICIENCY OF FOREIGN STUDENTS—Entering graduate students from countries other than the United States are required to demonstrate high level competence in the use of the English language, including reading, writing, speaking, and listening. Upon arrival at the University, such students are requested to report to the Office of International Student Affairs, where an appointment for the English language proficiency interview will be made. Students with an obviously good com-

mand of English will be exempted from formal testing; others will be scheduled for a series of proficiency tests. The Graduate School at The Pennsylvania State University requires all foreign graduate students who are working toward a degree to pass an English language examination. Remedial work will be prescribed as indicated by the tests.

Before a foreign student can be accepted for enrollment at The Milton S. Hershey Medical Center a high level competence in the use of the English language must be demonstrated by successful performance on the TOEFL (Test of English as a Foreign Language). Information on the time and place that this test is given in his geographical area can be obtained by writing to the Educational Testing Service, Box 592, Princeton, New Jersey 08540.

GUESTS OF THE UNIVERSITY—The President, on recommedation of the Dean of the Graduate School, will welcome as guests holders of earned doctor's degrees who may be visiting the University Park Campus for purposes of noncredit study. Guest privileges apply to persons holding the degree from The Pennsylvania State University or other accredited colleges and universities. Guests may attend seminars and courses and, if space and facilities are available, carry on research. There will be no charge except for laboratory expenses. Arrangements should be made in advance with the Dean of the Graduate School.

UNDERGRADUATE STUDENTS—A senior student of The Pennsylvania State University lacking not more than 4 credits for graduation may be admitted to the Graduate School. This limit may be increased to 8 credits in the case of a student with an average of at least B (a grade-point average of 3.00). Any senior with a 3.50 grade-point average may be admitted to 500-level courses with the consent of the instructor; other undergraduate students with a B average or better may be admitted to such courses with the consent of the instructor and the Dean of the Graduate School.

In certain cases undergraduate students may subsequently apply credits they have earned in 400 and 500 series courses toward an advanced degree at Penn State. Upon admission to the Graduate School such credits as are relevant to the graduate field of study and were not used to satisfy undergraduate requirements will be entered on the student's graduate transcript. These may then be applied toward an advanced degree provided they are acceptable to the major and minor departments. The time limitation on the completion of a master's degree program applies to these as well as to other credits.

UNSATISFACTORY SCHOLARSHIP

A graduate student who fails to maintain satisfactory scholarship or to make acceptable progress in his degree program will be dropped from the University. Action may be initiated by the department or committee in charge of the graduate major or by the chairman of the student's doctoral committee.

CLASSIFICATION

At the time of admission to the University a student is classified as a graduate, adjunct, or undergraduate student depending upon his objectives and qualifications. A graduate student may be admitted either as a degree student or a special nondegree student depending upon his objectives. After admission to one of these categories, any change to the other must be arranged through the Graduate School office.

DEGREE STUDENTS—Persons who plan to become candidates for advanced degrees at The Pennsylvania State University and who have been formally admitted for advanced study in a particular field are designated as degree students. The program of study is developed under the guidance of an adviser appointed by the head of the student's major department.

A degree student who has passed a candidacy evaluation is classified as a doctoral candidate.

SPECIAL NONDEGREE STUDENTS—An applicant who meets all requirements for admission to the Graduate School, but who does not wish to work for an advanced degree at this institution, may arrange for a program of work as a special nondegree student. This classification includes any who plan to transfer credits to another institution and those who plan special programs of study not leading to an advanced degree. The number of nondegree students who can be admitted is limited, and it is increasingly difficult to provide for them because of the limitation of total enrollment. Preference is given to students in degree programs.

If a special nondegree student wishes to consult an adviser, one will be appointed upon request to the department head most closely associated with the student's field of interest. The student's status and standing will be reviewed by the Dean of the Graduate School at each registration. He may remain a special nondegree student longer than one term only with the permission of the Dean, and for definite and good reasons.

ADJUNCT STUDENTS—An adjunct student is not a graduate student, inasmuch as he has not been admitted to the Graduate School, and may not register for graduate courses or research (500 and 600 series) without permission of the Dean of the Graduate School. An adjunct student may register for 400-level courses provided he has attained at least junior standing in college.

Credits earned as an adjunct student may not ordinarily be applied subsequently toward an advanced degree.

REGISTRATION

The responsibility for being properly registered rests with the student. At least until his program is near completion, he is expected to register for each term in which he proposes to do either course work or research toward his thesis, whether it be on or off campus. In the case of research, the number of credits shall be determined by the amount of time required for the investigation, one credit representing the equivalent of one week of full-time work. In the later stages of his program the situation will determine the requirements for the student's registration.

CONTINUITY OF REGISTRATION—A student who registers at University Park without interruption for each of the three terms in the September to June interval, for all four terms each year, or for each summer term is considered to have maintained a normal continuity of registration.

Anyone who has interrupted such a normal sequence and now plans to register for work at the University Park Campus is required to apply to the Dean of the Graduate School at least one month before the time of registration for permission to resume study.

The policy may be summarized for any specific term as follows:

Summer Term—Application required unless the student was registered at University Park for the preceding spring term or the preceding summer term.

Fall Term—Application required unless the student was registered at University Park for the preceding summer term or the preceding spring term.

Winter Term—Application required unless the student was registered at University Park for the preceding fall term.
Spring Term—Application required unless the student was registered at University Park for the preceding winter term.

PROCEDURE—For each registration the student, in consultation with his adviser, prepares a schedule of courses and research designed to fit his individual needs. The credit load will be reviewed by the Dean of the Graduate School at the time of registration. The registration process is completed in the manner specified for all students at the University.

Under certain conditions credit may be earned by work done away from the campus. A student contemplating such work should inquire of the Dean of the Graduate School about the procedures and conditions. The student must assume responsibility for the registration process, but the operation can be handled by mail. Registration must be completed before the close of central registration at University Park.

A student must register for courses audited as well as for those taken for credit.

REGISTRATION NEAR THE COMPLETION OF A PROGRAM—A candidate for the Ph.D. degree who is following the new regulations, which went into effect in the fall term 1967, is required to register continuously (at least three terms per calendar year) from the time he has both passed the comprehensive examination and met the three-term full-time academic requirement until his thesis is accepted by his doctoral committee, regardless of whether he is working on his thesis during this interval. These candidates are also required to be registered for the term in which they graduate.

Other doctoral candidates and master's students may be required to register for a normal credit load because of their appointment status. If not, and if they have earned more than 90 or 30 credits, respectively, and have met the requirements for their degrees except for the completion of the thesis, these students may register for as few as two credits per term. A student who has met the minimum requirements for his degree and is now completing his research and thesis writing off-campus is not required to register, even if he comes to the campus several times each term to see his adviser.

A student, other than one following the new Ph.D. requirements, is not required to register for his final term in order to graduate or in order to make minor revisions to his thesis and/or to take a final examination for his degree.

TIME OF REGISTRATION—Registration days are indicated in the calendar at the beginning of this bulletin.

A student is expected to complete his registration during the officially designated period and to attend the first meeting of all classes in which he is enrolling. If this is impossible because of some emergency or unusual circumstance beyond his control, the student may be granted permission by his instructor to miss a few class meetings, it being understood that work missed will be made up subsequently. Under these conditions the Dean of the Graduate School may grant the student permission to register late. In general, a student who receives permission to register late will be required to reduce his program in proportion to the length of time he has been absent.

Regardless of when he may begin attending classes, a student who fails to complete the process of registration within the officially designated registration period will be liable for the late registration charge.

LOADS, ACADEMIC AND EMPLOYMENT—Many students depend upon part-time employment to help meet their expenses. A student who is thus employed, however, must recognize the time demands of his work schedule in planning his academic program.

The University takes the position that the facilities of the Graduate School should be made available only to students who can profit from their Graduate School ex-

perience to a maximum extent. Therefore the Graduate School reserves the right to deny admission or registration to part-time students who (a) propose schedules of few credits which seem to reflect little real interest in graduate work or would not seem to require serious effort, or (b) wish to carry overloads of such proportion as to handicap them seriously in achieving maximum quality in their graduate work. The consequences of a graduate student changing his course load rests with the student and his adviser, not with the Graduate School.

Doing graduate work means more than doing what is required in courses or in research. It means living in a scholarly atmosphere and seriously engaging in scholarly pursuits. It means profiting from hearing visiting scholars and artists and from engaging in discussions, both formal and informal, with faculty members and fellow students. It should mean leisure time for reflection and for exploring fields related to, although not directly a part of, one's specialty. Overloads make it difficult and often impossible to do graduate work so conceived. The following schedule of credit loads for employed students is suggested:

EMPLOYMENT	ACADEMIC LOAD
0 hours per week	8-10 credits
10 hours per week	7- 9 credits
20 hours per week	5- 7 credits
30 hours per week	4- 5 credits
40 hours per week	1- 4 credits

This means, for example, that anyone working twenty hours per week (about half-time) whether as a half-time graduate assistant, as an employee on campus, or as an employee off-campus, may wish to limit the amount of graduate work for which he registers to about three-fifths of a normal full-time load (i.e., to 5-7 credits). The word "employment" is used in a very general sense and includes work for indirect compensation. All students who are thus employed may adjust their academic loads accordingly. Exceptions, in the case of students who have demonstrated unusual ability, must be arranged with the Dean of the Graduate School at the time of registration. (See also Visiting and Auditing Classes.)

A student holding a fellowship, graduate assistantship, or scholarship may not accept employment of any kind for service beyond that specified by his appointment.

VISITING AND AUDITING CLASSES—A graduate student who wishes to attend classes without receiving credit may secure permission either to visit or to audit courses during a term for which he has registered.

As a visitor, a student may attend classes with the approval of the instructor but may not claim the usual privileges of class membership such as participating in discussion, doing practicum work, or taking examinations. He does not register for the privilege of visiting, nor does any record appear on his transcript.

As an auditor, a student may participate in class discussion, do praticum work, take examinations, and generally share the privileges of a class member. The student registers in the same manner as if he were taking the course for credit and pays the same fees. He receives no credit and cannot subsequently secure credit for work done in the course; however, the Records Office shows on the grade report and the record the actual number of credits assigned to the course. Thus, when a student receives an audit grade, the number of credits which he audited is shown.

A student who, because of his status as a graduate assistant or fellow, is required to register for a certain minimum number of credits is not permitted to count those courses for which he is registering as an auditor for this purpose. The 1G and 2G language courses are an exception. Beyond the required minimum he may register for credit or audit but may not exceed the normal maximum without special permission.

In general, students are encouraged to visit classes rather than to register for a course as auditors. However, visiting is not permitted in German 1G and 2G.

In the 1G and 2G courses offered by the language departments, no distinction is made between registering for credit and for audit in considering loads. If the student does not have a reasonable background in the language, he will be required to count the course as part of his permissible load regardless of whether he registers for credit or for audit. If he has had the language before and is taking the course as a refresher, he may, with the permission of the Graduate Dean, take the course as an overload regardless of whether he registers for credit or audit.

SELECTIVE SERVICE—A request for deferment must be addressed to the local board by the student himself. The University can supply local boards with information needed in support of a request for deferment.

To have his local board informed of his formal admission to the Graduate School, a student must supply the essential Selective Service information and request the Records Officer to inform the board.

Under present rules, only two groups of graduate and professional students are eligible for II-S (student) deferments. If students enter graduate study in one of five medical fields—medicine, dentistry, osteopathy, optometry, or veterinary medicine—they must be given a II-S deferment as long as they are "satisfactorily pursuing" a degree. A graduate student in any other field in the Fall of 1968 or after may be given a II-S deferment at the local board's discretion, provided that student meets very limiting requirements. These requirements are best explained by the student's local board.

To have his local board informed of his registration and status as a student, a graduate student must request in person that the Records Officer so inform the local board. If so requested, a report will be sent shortly after the beginning of the first term for which the student registers. A student is certified to be a full-time student insofar as Selective Service is concerned if he schedules at least 8 credits (auditing a course does not count), or if he holds an appointment as a quarter-time or half-time graduate assistant, or if he is serving an internship or holding a traineeship under approved conditions.

If at any time a student changes his status from full-time to part-time, fails to make satisfactory progress, or makes a drastic change in his declared goal, his local board will be notified. If a student changes his status from part-time to full-time and wishes the local board to be informed, he must request the Records Officer to do so. When a student receives a master's degree, it will be assumed his program is terminated, and his board will be so informed unless there is clear prior indication in the Records Office of the student's intention of proceeding with a doctoral program.

If a graduate student, who is classified 1-A, receives an order for induction, that order will be postponed until after the end of spring term of that academic year. Upon notification from the student, the Records Office will verify the student's status to his local board.

GRADING SYSTEM

A grade is given solely on the basis of the instructor's judgment as to the student's scholarly attainment.

The following revised grading system is now in effect: Any one of five quality grades (A, B, C, D, F) may be given a graduate student for course work or for thesis research. The grade-point equivalents are 4, 3, 2, 1, 0, respectively.

At the 400, 500, and 600 levels grades of A, B, and C denote graduate credit, whereas D and F are failing grades for graduate students, D being the normal failing grade. A grade of F indicates doubt in the judgment of the instructor of the student's potential for further graduate study.

A minimum grade-point average of 3.00 for work done at the University is required for graduation in the case of all candidates whose first registration for graduate study at the University occurred in the spring term 1964 or later.

In addition to the quality grades listed above, two symbols, "Def." (deferred) and "R," may appear on a student's transcript. If work is incomplete at the end of a term for a reason beyond the student's control, or if very little work remains to be done, the instructor may report "Def." in place of a grade, which will appear temporarily on the student's record.

In the case of thesis work, either in progress or completed, and certain courses approved by the University Senate, the instructor may report the symbol "R" in place of a grade. This symbol indicates that the student has devoted an adequate amount of time to the work scheduled but gives no indication of its quality. An "R" remains on the student's transcript permanently. If, after having submitted a series of "R" symbols, the instructor reports a grade of A, B, C, D, or F for a specific term, this grade is considered to apply to the preceding series of registrations and to denote the quality of that entire series.

GRADUATION

It is the responsibility of the student to inform the Graduate Recorder of his intention to graduate (by filing a diploma card) and to pay thesis fees at the beginning of the term in which he expects to receive an advanced degree. If he does not graduate that term, he must reactivate the diploma card by indicating to the Graduate Recorder the term in which he intends to graduate. Deadlines are given in the calendar found at the beginning of this bulletin.

See the *Manual for Graduate Students* for a detailed statement of procedure concerning graduation. Attendance at commencement exercises is expected, but permission to receive the degree in absentia may be granted by the Dean of the Graduate School.

All degrees conferred are tentative until final grade reports have been received, even though the student's name may have appeared in the commencement program.

TUITION AND CHARGES

The University reserves the right to revise the schedule of tuition and charges without further notice.

TOTAL TUITION FOR EACH TERM

University Park Campus and Medical Center—8 or more credits, total charge of $260 for Pennsylvanians and $600 for non-Pennsylvanians; 7 or fewer credits, $32 per credit for Pennsylvanians and $75 for non-Pennsylvanians. These rates apply also to off-campus research and other approved individual study.

Graduate Centers—8 or more credits, total charge of $250 for Pennsylvanians and $600 for non-Pennsylvanians; 7 or fewer credits, $28 per credit for Pennsylvanians and $75 for non-Pennsylvanians.

Continuing Education Centers—University Park, $32 per credit for Pennsylvanians and $75 per credit for non-Pennsylvanians; Graduate Centers, $28 per credit for Pennsylvanians and $75 per credit for non-Pennsylvanians.

Vocational Education Program—8 or more credits, total charge of $260 for Pennsylvanians and $600 for non-Pennsylvanians; 7 or fewer credits, $32 per total program for all students (vocational education courses are indicated by "v" following the course number).

Tuition is the same for courses whether audited or taken for credit.

Any student who does not fulfill payment obligations promptly may be charged a late payment fee of $25. A student whose account is delinquent for more than ten days is subject to suspension from the University.

Whenever it appears that an applicant for admission is not domiciled in Pennsylvania, it is assumed that he is a non-Pennsylvanian. If the student who is thus admitted believes that his circumstances do not justify his classification as a non-Pennsylvania, he may petition the Graduate Dean's office for reclassification.

When a petition for reclassification is made, the petitioner is required to present proof of a bona fide continuous domicile other than as a student of the one admitted (or of his parents, if he is a minor) within the Commonwealth for a period of at least twelve months immediately preceding the date of registration for courses, or such other evidence as is pertinent to a complete review of his classification.

Any student who changes his domicile while attending the University is subject to reclassification effective at the beginning of the first term following notification to the Graduate School that such a change has taken place.

TUITION REFUND POLICY—Charges for tuition are refundable upon withdrawal from the University only in the event the student obtains an Official Withdrawal Form at the office of the Dean of the Graduate School and presents it, together with his current Certificate of Registration, at the office of the Fee Assessor no later than one calendar month after the effective date of withdrawal from classes. Students who meet these conditions are entitled to receive refunds of charges for tuition for the term in accordance with the following schedule:

> Refund of 80 per cent upon withdrawal before the end of the first week of the term (seventh consecutive calendar day from the first day of classes) and a decrease of 20 per cent for each week thereafter up to and including the fourth consecutive calendar week. No amount will be refunded for withdrawal after the fourth consecutive calendar week of the term.

The University will not release any refund of tuition until at least three weeks have elapsed from the date the payment was received. All refunds will be made by check and mailed to the student's home address.

SPECIFIC CHARGES—In addition to the foregoing tuition and charges, the following charges apply under special conditions and are to be paid independently:

Application fee	$ 15.00
Change of schedule, each change	2.00
Duplicate meal ticket	1.00
Duplicate student identification and activity card	each 4.00
French reading examination	6.00
Music, individual lessons	30.00 to 100.00
Privilege of late payment	25.00
Privilege of late registration	10.00
Special dissertation fee for Ph.D. candidates (601)	75.00
Special dissertation fee for Ph.D. candidates (611)	25.00
Student parking fee, each term	10.00
Teacher placement service registration fee	5.00
Teacher placement service reactivation fee	5.00
Thesis binding fee for master's candidate	10.50
Thesis microfilming and binding fee for doctoral candidate	45.50
Transcript of records (with seal), each copy	1.00

MOTOR VEHICLE CHARGES—Each graduate student who possesses, maintains, or operates a motor vehicle (including a motorcycle, motor bike, motor scooter, or any other motor-driven vehicle) in Centre County is required to register such vehicle with the Traffic Violations Officer during the registration period of each term. There is no charge for registration for students who do not desire campus driving or parking

privileges. Failure to register a vehicle renders a student liable for a fine of $15 for each offense.

A permit allowing limited driving and parking on the campus throughout the week costs $10 per term. A more restricted permit allowing driving and parking on the campus for evenings and weekends costs only $3.50 per term.

A graduate assistant pays no fee for the privilege of driving and parking on the campus but is required to comply with student regulations concerning motor vehicles.

The Pennsylvania Bureau of Motor Vehicles has adopted the following policy concerning registration of motor vehicles by out-of-state students:

> If a student lives for more than thirty consecutive days in the year in Pennsylvania, he shall be required to obtain Pennsylvania registration for his vehicle. We know, however, that any student with a motor vehicle will visit the states adjoining Pennsylvania from time to time, in which event he will not be living thirty consecutive days in Pennsylvania. For the purpose of administering our registration law, we shall assume in the absence of definite proof to the contrary that students have not maintained a place of abode in Pennsylvania for more than thirty consecutive days in the year and therefore, are not subject to Pennsylvania registration.
>
> NOTE: Students teaching part-time to help pay school expenses do not lose their status as students. (Correction, January 15, 1955).

Since graduate assistants are students by definition, this policy is applicable unless the student is employed on a full-time basis. The policy is not necessarily followed by local enforcement agencies if such agency has proof that the student has in fact lived in Pennsylvania for thirty (30) consecutive days. There is no policy for dependents of students, including spouses. Therefore, a spouse may be subject to prosecution by a local enforcement agency even if the student spouse is exempt under the above quoted policy.

A graduate student planning to operate a motor vehicle in the Centre County area should secure a copy of the leaflet *Parking and Traffic Regulations* from the Traffic Violations Officer.

LIVING ACCOMMODATIONS

Eastview Terrace and Graduate Circle, both located on the eastern side of the campus, provide one- and two-bedroom apartments for married graduate students.

The Eastview Terrace apartments are fire resistant, one-story, steel framework buildings. Forty-six one-bedroom units rent for $80 per month; thirty-two two-bedroom units rent for $90. The rent includes utilities except electricity. Water is heated electrically. The units are unfurnished except for electric stove and refrigerator. For each two units there is a utility room with two stationary laundry tubs and storage space.

Graduate Circle has 144 one-bedroom and 72 two-bedroom apartments in sixteen two-story buildings of brick and frame construction. The units rent for $90 and $100 per month, including all utilities. Each kitchen has a double stainless steel sink with disposal unit, a gas stove, kitchen cabinets, and an electric refrigerator; each bedroom has a built-in chest of drawers. Otherwise the units are unfurnished. There are no facilities for private washing machines in the apartment; however, coin-operated laundries at nominal fees are provided in five of the buildings throughout the area. A storage locker is also provided for each apartment at the laundry location.

Families with children of school age, or with children who will become of school age during the term of the lease, cannot be considered for occupancy in Eastview Terrace and Graduate Circle. The one-bedroom apartments are designed for a husband and wife and the two-bedroom units for a family with not more than two children. An agreement form for graduate housing may be obtained by submitting the "Request for Graduate Housing" card. This request card is to be mailed to the

Assignment Office for Campus Residences, 101 Shields Building, University Park, Pa. 16802. Telephone: Area Code 814, 865-7501.

Atherton Hall, located near the Hetzel Union Building, and McKee Hall, located near the Graduate Center, are reserved exclusively for single graduate men and women, providing residence hall room accommodations without food service. Double, single, or single occupancy of double rooms are available at $150, $185, and $200 per term, respectively. Fall Term Housing and Food Service Agreements must be submitted, with $45 advance payment, to the Bursar's Office, 103 Shields Building, University Park, Pa. 16802. THE ADVANCE PAYMENT WILL BE REFUNDED IF ASSIGNMENT OFFICE FOR CAMPUS RESIDENCES, 101 SHIELDS BUILDING, IS NOTIFIED OF CANCELLATION NO LATER THAN JULY 15, OF EACH YEAR. AGREEMENTS FOR WINTER, SPRING, AND SUMMER TERMS DO NOT REQUIRE AN ADVANCE PAYMENT AND SHOULD BE MAILED DIRECTLY TO THE ASSIGNMENT OFFICE FOR CAMPUS RESIDENCES, 101 SHIELDS BUILDING, UNIVERSITY PARK, PA. 16802. STUDENTS NOT CANCELLING AS OF THIS DATE, WILL BE OBLIGATED FOR THE ONCOMING FALL, WINTER, AND SPRING TERMS, IF THEY ARE ENROLLED AT THE UNIVERSITY PARK CAMPUS. The Hetzel Union Building cafeteria and snack bar are available for meals.

Separate dining hall meal tickets for one of eight campus dining halls may be purchased for $220 per term. Twenty-one meals per week are served beginning with registration and ending with final examinations.

For other information about the residence or dining halls, contact the Assignment Office for Campus Residences, 101 Shields Building, University Park, Pa. 16802. Telephone: Area Code 814, 865-7501.

Other living accommodations available in the community may be located through the Chamber of Commerce, 129 West Beaver Avenue, State College, Pa. 16801; Telephone: Area Code 814, 237-7644. The cost of apartments or rooms in private homes or lodging houses varies considerably, depending upon the type of accommodations desired. Arrangements can best be made by a personal visit to the area.

Graduate students should arrange for their accommodations well in advance of the beginning of classes because it may be very difficult to find convenient housing at the last minute. STUDENTS MUST BE ADMITTED TO THE GRADUATE SCHOOL BEFORE THEIR REQUESTS FOR ON-CAMPUS LIVING ACCOMMODATIONS CAN BE PROCESSED.

LIFE AT PENN STATE

The community of State College and the University Park Campus combine to provide a stimulating, intellectual, and aesthetic atmosphere by combining a wide variety of outdoor recreational activity with the rich cultural offerings of a fine university center. It is located on a plateau 1,200 feet above sea level and is surrounded by low-rolling hills, largely covered with verdant evergreen forests intermixed with deciduous trees which set the landscape aglow with brilliant hues during the fall months. Sprawling, well-kept farmlands and homes present a pleasing atmosphere, with many fine continuously-flowing streams and numerous ponds and small lakes. Herds of cattle, which form one of the larger industries in the state, roam in fields of rich pasture.

The public school district of State College, with a population of about 42,000 has a pleasant small-town atmosphere with big-town facilities and entertainment. The community has two daily newspapers, two AM and three FM radio stations, twenty-four churches, and more than one hundred active social and civic organizations. "Dames" form a social group of graduate student wives. A variety of programs in the areas of the arts and recreation keep the intellectual atmosphere stimulating and

afford physical relaxation and enjoyment. The University gymnasia for men and women include swimming pools, basketball courts, bowling alleys, handball courts, squash courts, and a variety of facilities for individual exercise. There is a large indoor skating rink, forty tennis courts, a thirty-six-hole golf course, the Natatorium with three pools plus an Olympic-sized outdoor swimming pool, numerous softball courts, and intramural fields. For spectators, the University has thirteen varsity sports; the football and gymnastics teams, in particular, rank among the best in the country.

Art: There is a myriad of cultural experiences for art lovers to enjoy, a continual turnover of exhibits in various buildings on campus, both private and on loan, as well as those on permanent display, offer opportunity for individual artists to receive personal recognition.

Music: For the music lover, a rich and varied fare is provided by the University Artists and Lecture Series, the State College Choral Society's Chamber Music Series, and University musical organizations. For the singer, the latter include the University Swingers, the Men's Glee Club, the Chapel and Concert Choirs, the Tour Choir, and the Penn State Singers—a mixed group which sings early church music, madrigals, chamber operas, and cantatas. For the instrumentalists, prominent in appeal are the Penn State Blue Band, the Penn State Concert Band, and the University Symphony Orchestra. The University's resident Alard String Quartet performs with the Symphony Orchestra and, in addition, presents a number of individual programs throughout the school year. The Department of Music schedules weekly performances by students, staff, and visiting musicians.

Community musical organizations provide opportunities for participation as well as listening. Local choirs invite student membership. The Christmas Community Sing is presented each year by a 150-voice chorus made up of singers from local choirs and interested students and townspeople. There is an active SPEBSQSA (Society for the Preservation and Encouragement of Barbershop Quartet Singers in America) chapter which encourages student participation and imports "big quartets" for its annual show. There are a number of barbershop quartets active on campus.

Theatre: The University Theatre produces plays on a year-around basis, operating in two modern theatres, the Playhouse and the Pavilion. During the summer months, a professional company augmented by student apprentices comprise the Festival Theatre. Auditions throughout the year are open to all students. Specially priced student tickets are available. During the academic year, two other workshop groups operate under Theatre Arts supervision: the Experimental Theatre and the Five O'Clock Theatre, the latter producing original plays written on campus.

An independent student dramatic group, Thespians, produces two musical shows each year. University Readers give students interested in reading aloud an opportunity to share this interest with others in the weekly interpretive workshop. Numerous other groups sponsor films and dramatic presentations of special interest. One example of this is the International Film Society, which offers foreign films. Local dramatic groups, theatres, and the Central Pennsylvania Festival of the Arts offer further cultural opportunities within this area.

The State College Community Theatre also presents a regular schedule of productions throughout the year, with an expanded weekly schedule during the summer months at nearby Boal Barn Playhouse.

Lectures: Scores of nationally and internationally known visitors come to the campus every term. Many of them speak under the sponsorship of the Artists and Lecture Series, the College of Education Lecture Series, and the Liberal Arts Lecture Series, or in less formally organized programs sponsored by departments, honor societies, scientific and technical organizations, professional groups, clubs, and special interest groups.

Recreation: The State College Community has two borough parks, a community playing field, two community swimming pools, numerous tennis courts, a Little

League, and nine supervised playgrounds. There are also four bowling alleys and four golf courses in the area, in addition to the University facilities.

Area parks include Black Moshannon State Park, Poe Valley State Park, and Greenwood Furnace State Park, where swimming, camping, picnicking, and fishing are available. Whipple's Dam State Park is popular for swimming, fishing, and picnicking. Stone Valley, the University's recreational area, offers sailing, picnicking, and fishing. An hour's drive away is Prince Gallitzen State Park, which has a large lake for sailing, motor boating, swimming, picnicking, and camping.

Fishing is excellent in the area, as streams are stocked with brook, brown, and rainbow trout; pickerel, bass, and pan fish are also available. Penn's Creek nearby is regarded as one of the nation's best trout streams. Fisherman's Paradise, also nearby, is famous for its trout fishing.

Hunting is also good, as state game lands surround State College. Deer and bears are most abundant. Other prospects include wild turkey, ruffed grouse, ringneck, pheasant, rabbit, raccoon, mink, skunk, woodchuck, and squirrel.

Skiing facilities are available at Skimont just outside State College, with trails and slopes from 1,700 to 3,200 feet, rope tows, and T-Bar lift. Facilities are also available at Black Moshannon State Park, where two poma lifts are operated. Also, it is only a little over an hour's drive to the Blue Knob Skiing area—a skier's paradise.

Caves occur all over the limestone country of Centre County. Commercial caves include Indian Cave, Woodward Cave, Alexander Caverns, and Penn's Cave—the only all-water cavern in America. There are also numerous noncommercial and unexplored caves which are the delight of local spelunkers.

STUDENT SERVICES

RITENOUR HEALTH CENTER—Located in the central campus area, the Ritenour Health Center is the core of the health service activities and is composed of a dispensary and a hospital. Its facilities are available to full-time graduate students, that is, students registered for eight or more credits or the equivalent (students holding quarter-time assistantships scheduling 7-9 credits, or students holding half-time assistantships scheduling 5-7 credits). The out-patient dispensary handles medical problems of the students from 8:00 a.m. to 11:45 a.m. and from 1:30 p.m. until 4:45 p.m. daily except Saturdays, when hours are from 8:00 a.m. to 11:45 a.m. During other periods, including Sundays and holidays, patients are seen for emergencies only in the Emergency Room of the University Hospital, which is part of the Health Center complex.

The University Hospital is well equipped to handle the more serious illnesses and injuries on an in-patient basis. A 65-bed facility, it is staffed with professional personnel twenty-four hours a day during the school terms. Should the need arise for special medical or surgical treatment—major surgery, for example—the student is transferred to a hospital facility of his choice.

Included in the Health Center facilities are a dental office for emergency dental care, a physiotherapy department, and a pharmacy.

Hospitalized students will be charged $10.00 per day during confinement, and a nominal charge will be made for all drugs dispensed to hospitalized or dispensary patients. A standard laboratory and X-ray fee is charged for examinations done in the Health Center when ordered by physicians other than the members of the Health Center staff. Consultation with or treatment by physicians other than the professional staff at the Health Center shall be at the student's expense.

Health Center physicians do not make calls for treatment of students in their rooms. If the ill student prefers to receive treatment in his room on his own responsibility, he should call one of the practicing physicians in the community. An exception to this rule may be made by the University physician in critical emergencies.

The Ritenour Health Center maintains an ambulance service for local transportation of students with nonambulatory illnesses and injuries.

INSURANCE PROTECTION WHILE ATTENDING THE UNIVERSITY—The Pennsylvania State University is an instrumentality of the Commonwealth performing its function of education. It is not liable for the negligence of its officers, servants, and employees when in the exercise of public or governmental powers or in the performance of public or governmental duties incident to the general educational work of the University.

Therefore any student who desires insurance protection while in attendance at the University (1) against personal injury and/or (2) against loss of property by fire or theft should arrange personally for whatever insurance seems advisable.

HEALTH INSURANCE PLAN—A voluntary Accident and Sickness Insurance Plan with a variety of benefits is available to graduate students and their dependents, provided the student is eligible for the services of the Ritenour Health Center. For further information, call the local representative for the student insurance carrier (telephone Area Code 814, 238-6725), or write to Graduate Student Health Insurance Plan, Graduate School Office, 205 Graduate Building, University Park, Pa. 16802.

PLACEMENT SERVICE—The University Placement Service, in cooperation with all the colleges and departments of the University, assists both graduate and undergraduate students in finding appropriate employment upon graduation. In addition, services are extended to alumni. Among the services offered are: (1) career counseling concerning career planning, career opportunities, employer characteristics, and employment trends; (2) a library of information about employers, employment trends, and career opportunities; (3) the scheduling of interviews with employers visiting the campus; (4) an extended file of employment opportunities for which a student may apply by mail; (5) a listing of summer jobs and internships appropriate to the student's career interests; and (6) conducting of appropriate research. These services are closely coordinated with the Division of Counseling.

Contact is maintained with several thousand employers in education, industry, and government. Information concerning employment opportunities is routinely distributed to all academic departments.

The general placement section concentrates on employment possibilities in industry and government. The educational placement section concentrates on administrative, teaching, and service opportunities in universities as well as in elementary and secondary schools.

RELIGIOUS PROGRAMS—The University seeks to serve the spiritual needs of its students and staff. General responsibility for religious activity on the campus rests with the University Coordinator of Religious Affairs. Individual organizations under the sponsorship of members of the Jewish, Protestant, and Roman Catholic faiths serve the student body. Many other religious organizations, including denominational and interdenominational groups, are active on the campus and in association with local churches.

GRADUATE STUDENT ASSOCIATION—Established in 1951 at the suggestion of a group of students and faculty members, the Graduate Student Association functions as the official spokesman for graduate students, all of whom are automatically members. It is the particular function of the organization to give to the individual member the opportunity to express and ameliorate problems through discussion and collective action, intellectual stimulation of interests, and the occasion for relaxation through its social program. The University makes an appropriation to the Association in lieu of dues.

The Association has a council which consists of elected representatives from every graduate department with voting rights roughly proportionate to the number of students in any given department, nonvoting *ex officio* representatives from graduate

living units, representatives to committees outside the Graduate Student Association, and an Executive Board. The council meets regularly to conduct the business of the Association; the Executive Board has interim powers to conduct business not requiring the specific action of the Council of Representatives. The executive secretary from the board acts as the official liaison between the council and the Dean of the Graduate School.

The Association has an office at 305 Graduate Building where it keeps its records and conducts its business. Its faculty adviser is chairman of the Graduate School's Student Affairs Committee. Members of the Graduate Student Association Council or the Graduate Student Association are selected by the council to serve as members of various Graduate School committees. In addition, the Graduate Student Association elects four graduate students to serve as voting members on the University Faculty Senate and five voting members on the Graduate Council. Members of the Graduate Student Association are elected.

The Graduate Student Association has created the following standing committes:

1. Housing Committee
2. Program Committee
3. Graduate Center Committee
4. Academic Affairs Committee
5. Rules Committee
6. Public Relations Committee
7. Educational Opportunity Committee
8. Senate Coordinating Committee
9. University Affairs Committee
10. International Student Committee

In addition, the council may institute ad hoc committees or presidential commissions at will. Every council member is assigned to a standing committee. Other members of the University community may serve on committees.

The Association maintains communication with graduate students through the campus daily newspaper and by other appropriate means, such as a newsletter.

MASTER'S DEGREES

The Graduate School recognizes a difference in purpose, which is reflected in the requirements, for two types of advanced degrees, academic and professional. Of the twelve master's degrees conferred, the Master of Arts and the Master of Science are academic in nature. The professional degrees conferred are Master of Administration, Master of Agriculture, Master of Business Administration, Master of Education, Master of Engineering, Master of Environmental Pollution Control, Master of Fine Arts, Master of Forestry, Master of Public Administration, and Master of Regional Planning.

A degree is not conferred for a mere collection of credits. A well-balanced, unified, and complete program of study will be required, which may frequently exceed the minimum requirements specified below.

A student may meet the degree requirements by either full-time or part-time enrollment and by attendance in any combination of terms. The student who interrupts the continuity of his registration faces the possibility of not being granted permission to return.

GRADE-POINT AVERAGE—A minimum grade-point average of 3.00 for work done at the University is required for graduation in the case of all candidates whose first registration for graduate study at the University occurred in the spring term 1964 or later.

TIME LIMITATION—All requirements for a master's degree, whether satisfied on the University Park Campus or elsewhere, must be met within six years or a period spanning seven consecutive summers.

MASTER'S DEGREES

ADMISSION—In addition to the general University requirements for admission set forth at the beginning of this bulletin, adequate undergraduate preparation is required in the field in which the applicant expects to pursue advanced work. The specific courses and the total number of undergraduate credits required in various areas will be determined by the choice of field and can be ascertained from the descriptive statement appearing under the major field heading in the latter portion of this bulletin. An applicant who meets the necessary grade-point average but is deficient in course preparation may, under certain circumstances, be admitted to the Graduate School and allowed to make up the undergraduate deficiencies. Under these circumstances the program will require more than the necessary period of residence. An applicant for admission to the M.Ed. program in most major fields is required to have had at least 18 credits in education and related psychology, and in certain major fields may be required to have had practice teaching.

After a student has been admitted to a degree program, he should confer with the head of his major department concerning the appointment of an adviser. The general guidance of a master's candidate is the responsibility of an adviser, or of a committee appointed in a manner to be determined by the major department in which the student is specializing. The adviser or the committee assists the student in planning a program of study. Although the adviser is frequently the supervisor of the thesis, this is not necessarily the case.

Requirements concerning courses, language proficiency, minors, comprehensive examinations, and other matters are sometimes made by departments in addition to (but not in conflict with) the regulations of the Graduate School. For details the student should consult the head of the major department.

TRANSFER CREDIT—Subject to the limitations given below on the use of credits earned away from the University Park Campus, a maximum of 10 credits of high quality graduate work done at another institution may be applied toward a master's degree here.

The student should distinguish carefully between the transferability of credit and its applicability in a particular degree program. When transfer credits are accepted at the time of admission, the student in not really assured of their applicability in his program until he has consulted his adviser and the details of his graduate program have been worked out.

EXAMINATIONS—In addition to the examinations specifically required by the regulations of the Graduate School, a candidate may be required to pass in a satisfactory manner such other written or oral examinations as his department may designate. A candidate should consult his major department for such special requirements.

Examinations to establish credit for work done *in absentia* or without formal class work may be used to remove undergraduate deficiencies, but *not* to earn credits toward an advanced degree. Arrangements are made by the student directly with his major department.

Graduate Record Examinations are designed to test information and abilities in basic fields of knowledge. Provisions are made on the campus for administering these examinations at scheduled times and upon request of students or departments. Further information may be obtained from the Office of Graduate Student Programs.

M.A. and M.S.—ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Arts and the Master of Science degrees have similar requirements, the general major area determining which degree is conferred. Programs for both degrees are strongly oriented toward research.

A minimum of 30 graduate credits is required, of which at least 20 must be earned on the University Park Campus or at The Milton S. Hershey Medical Center. A minor

is not required of all candidates for M.A. or M.S. degree. A department or committee in charge of a major field may require a candidate to offer work in a minor field, or a student may elect such a program with the permission of his committee.

A minor consists of no fewer than 6 credits of integrated or articulated work in one field related to, but different from, that of the major. A minor program must meet the approval of the departments or committees responsible for both the major and minor fields.

The major department or the committee in charge of the major field is the judge as to the suitability of a field for the minor and of its relevance to the major. The minor department has the responsibility of accepting or rejecting students, advising on courses to be taken by the candidate in its field, examining the candidate in the area of studies he has undertaken in its field, and certifying that the minor requirements have or have not been met.

At least 18 credits in the 500 and 600 series combined must be included in the program. A minimum of 12 credits in course work (400 and 500 series), as contrasted with research, must be completed in the major field. A thesis is required of many candidates for these degrees. Details are given in the introductory paragraphs under the major field headings in the latter part of this bulletin. If a student is required to write a thesis, at least 6 credits in thesis research (600 or 610) must be included in his program. If no thesis is required, at least 18 credits must be in 500 courses.

Those candidates who are not required to write a thesis must present a suitable essay or paper. Its nature and extent shall be determined by the major department. The department shall report to the Dean of the Graduate School the title, the name of the faculty member under whom the student did the work, and whether the work was considered adequate. The department may require one or more copies of such an essay for its library or other files.

A thesis is prepared under the direction of the department in which the candidate's major work is taken. Under certain conditions a student may complete the thesis off-campus. To do so he must make satisfactory arrangements in advance with his adviser and the head of his major department.

The Capitol Campus—The Master of Arts in humanities aims at developing skills in the interdisciplinary study of art, music, literature, and philosophy. Entering students are expected to have considerable background in at least two of those areas. A committe will meet with each student to determine his individual needs and arrange a program designed to help him develop essential skills, such as analysis and critique of music, art, literature, and philosophy; classification of works into genres, periods, and schools; evaluation of works by applications of appropriate criteria; and synthesis and generalization. For students who plan to teach in a junior college, there is also provision for an internship program.

A series of seven 500-level courses are designed to help a student develop a number of these skills. In addition, his adviser may suggest he enroll in certain 400-level courses or in independent studies with qualified faculty.

Each student is required to submit a master's production (a critical paper or a creative work accompanied by a paper) which will demonstrate his competence in humanistic study. A committee will judge this production.

This program is available only at the Capitol Campus.

A Thesis Information Bulletin, which gives details concerning format, paper, illustrations, and other items, may be obtained at the Graduate School Office of Theses and Publications, 320 Graduate Building.

M.Adm.—ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Administration degree program is designed to meet the professional needs of practicing and potential administrators. A basic premise is that administra-

tion is a necessary function in all organizations and that it requires a common body of knowledge and skills regardless of its area of application. A total of 30 graduate credits is required—18 in the core courses and 12 in the area of specialization or option—with the majority of the courses at the 500 level. Three option areas are offered: business administration, engineering administration, and public administration. Each student is required to complete a research project in the field or in a laboratory in which he applies research methods and tests his solution through experimentation or simulation. The report must be of the quality, if not the theoretical depth, of a graduate thesis and must be defended before a committee of Graduate Faculty members. The candidate will be expected to demonstrate his ability to integrate knowledge of a specialized area with a broad understanding of the general field of administration.

The program is offered only at the Capitol Campus.

M.Agr.—ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Agriculture is a professional degree. Thus, programs leading to this degree provide opportunities for students to increase their knowledge and competences in the various phases of agriculture. A student, according to his needs, may obtain (1) intensive training encompassing a wide spectrum of subject matter area or (2) intensive training in a specialized area. The emphasis of the program is to enable students to develop skill as professional practitioners in the communication of technical knowledge and its application to the solution of current and future technical, economic, and social problems of individuals and groups.

The head of the department shall appoint a three-member committee to guide and monitor the candidate's professional development. Members of this committee must represent at least two departments. The chairman of the appointed committee shall serve as the candidate's adviser. Early in his program, the candidate will inform the committee of his background and aspirations. The committee will suggest to the student how best to achieve these goals and the standard of professional competence required for the Master of Agriculture degree.

A minimum of 30 graduate credits is required of which 20 credits must be earned in residence at the University Park Campus. A maximum of 10 credits may be earned in special problem type courses.

The candidate must present an acceptable paper on a selected professional problem, or a report of internship training. Up to 3 graduate credits will be given for an acceptable paper. The candidate may be required to provide one or more copies of the paper for the University.

The candidate's committee shall report through the department head to the Dean of the Graduate School the title of the paper and whether the paper and the candidate's academic performance were considered satisfactory.

M.B.A.—ADDITIONAL SPECIFIC REQUIREMENTS

The purpose of the Master of Business Administration degree program is to develop professional managerial knowledge and skills as these are applied to the decisions in business enterprises. Teaching focuses upon the techniques, the theory, and the skills important to modern administrators.

At least 36 graduate credits are required of which 18 or more are to be completed at the 500 level and 26 hours at University Park. Candidates who are admitted with-

out an undergraduate business background may be required to undertake up to 30 hours of work preparatory to full status as a M.B.A. candidate. During the later stages of course work, some specializations within a major area of student interest and a M.B.A. project paper are undertaken. Applications must include the results of the Admission Test for Graduate Study in Business sent directly from the Educational Testing Service.

M.Ed.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Education provide preparation for increased professional competence in the several fields of education. They should be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Arts or Master of Science. In most major fields the requirements for admission include 18 credits in education and related psychology.

A minimum of 30 graduate credits is required for the degree, of which at least 20 must be earned on the University Park Campus; at least 24 must be in course work. This degree is offered also at the Capitol Campus and the King of Prussia Graduate Centers.

MAJORS IN THE FIELDS OF EDUCATION—A student may major in one of the approved fields of education, such as elementary education, art education, or home economics education, and proceed under the guidance of the appropriate department of education.

A program of this type requires at least 6 credits to be earned outside the fields of education.

MAJORS OUTSIDE THE FIELDS OF EDUCATION—A student who is preparing to teach in a specific subject-matter field, such as geography, mathematics, or German may choose such a field as his major and take the majority of his work in it under the guidance of the department offering that major. A student wishing to work in a broader area may choose a major such as biological science, earth sciences, physical science, or social studies and take at least 24 credits in the area under the guidance of the committee in charge of the major.

Each candidate is required to earn 6 credits in education as directed by the faculty of one of the approved graduate programs in education. The 6 credits may be taken in educational foundations, which includes courses in comparative education; history, sociology, and philosophy of education; and educational psychology.

THESIS OR PAPER—Six credits may be granted for an approved thesis. A candidate who does not elect to write a thesis is required to present an essay or paper. It must be of considerable proportion, indicating capacity to describe a serious intellectual experience adequately in writing, and giving unmistakable evidence of ability to formulate and state meaningfully the purpose of an investigation, study, critical analysis, or evaluation; to acquire and analyze information; to draw conclusions logically; and to relate findings to professional problems and practices. The nature and extent of such a piece of writing, whether it be required in connection with a course or independently of course work, and when it is to be undertaken shall be determined by the major department. The department shall report to the Dean of the Graduate School the title, the name of the faculty member under whom the student did the work, and whether the work was considered adequate. It is the right, but not the responsibility, of the department to require one or more copies of such an essay for its library or other files.

M.Eng.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Engineering provide training for advanced professional competence in the several fields of engineering. They should be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Science.

A minimum of 30 graduate credits is required, of which at least 12 must be earned in graduate courses (500 series).

A scholarly written report on a developmental study involving at least one area represented in the candidate's course work is required as an integral part of the program. The report must be comparable in its level of work and quality to a graduate thesis. The topic of the developmental study is subject to prior approval by the department in which the candidate's major work is taken, and preparation of the written report shall be under the direction of that department.

No work for this degree is required to be done specifically on the University Park Campus provided the major department or supervisory committee and the Dean of the Graduate School agree that a complete program of study can be pursued at an established Graduate Center of The Pennsylvania State University.

M.E.P.C.—ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Environmental Pollution Control is an interdisciplinary professional degree designed for students who are interested in pursuing a career in the field of environmental pollution control. Special requirements include 9 credits of core courses covering air and water pollution control and solid waste management and participation in the environmental pollution control seminar program. A minimum of 30 graduate credits are required of which at least 9 must be at the 500 level and 20 must be taken at the University Park Campus. A thesis will be optional. If a thesis is written, at least 6 credits of thesis research (600 or 610) must be taken.

M.F.A.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Fine Arts provide training for increased professional competence in the several specialized areas of the arts. They should be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Arts with a major in art, music, or theatre arts.

A minimum of 48 credits is required, of which at least 38 must be earned on the University Park Campus. The larger part of these credits should be above the 400 level, but the needs of the student shall be considered in arranging the best combination of courses and research for the preparation of the candidate in his particular field.

A professional project, either creative or interpretative, is required. This project shall include a monograph in support of the creative or interpretative aspect; such monograph shall represent a minimum of 6 credits on the 600 level.

M.F.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Forestry provide training for increased professional competence in the several specialized areas of forest resource management and forest products. They should be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Science with a major in forest resources.

A minimum of 30 graduate credits is required, of which at least 20 must be earned on the University Park Campus.

A candidate for the degree of Master of Forestry should choose one area for his major and one or two related areas for his minor. The proportion of credits to be taken in the major and minor fields of study will be determined in consultation with the student's advisory committee. It is expected that the larger part of the program shall be in graduate courses (500 series), but no specific number of credits in the 500 series is required.

Each candidate is required to submit an acceptable thesis based on at least 6 credits of thesis research.

M.P.A.—ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Public Administration is a professional degree for students who are planning careers in public administration in local, state, and national governmental jurisdictions, or in international, private, or voluntary agencies. This program should be distinguished from the research-oriented program which leads to the academic degree of Master of Arts with a major in political science in which the candidate may specialize in public administration.

For the M.P.A. degree a minimum of 30 graduate credits is required, with the greater portion of the courses being at the 500 level. An M.P.A. essay or paper will also be required but will carry no graduate credit. A comprehensive final examination will be given to all candidates.

No work for this degree is required to be done specifically on the University Park Campus provided the major department or supervising committee and the Dean of the Graduate School agree that a complete program of study can be pursued at an established Graduate Center of The Pennsylvania State University.

The degree is a terminal one, and credits earned in the program may or may not be applicable, even in part, toward a doctorate.

M.R.P.—ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Regional Planning is a professional degree for students interested in a coordinated attack on the problems of community development and resource management. The program is intended to acquaint the student with rational programs of spatial allocation of land uses and facilities, maintenance of cultural and aesthetic values, and legal and governmental techniques for their implementation.

A minimum of 45 graduate credits is required. At least 36 credits are required in planning courses, of which 9 will be devoted to a group regional planning project or a problem-oriented thesis. A student who does not submit a thesis will present a project report, comparable in quality and scope to a graduate thesis.

This degree is also offered at the Capitol Campus Graduate Center.

DOCTORAL DEGREES

The Doctor of Philosophy, an academic degree, and the Doctor of Education, a professional degree, are conferred by the University. Recognized as different in purpose, the two programs consequently have different requirements in certain respects.

ADMISSION—A sudent who has been admitted to the Graduate School and has been accepted by the department or committee in charge of a major field in which the doctorate is offered may begin working toward a doctor's degree. However, he has no official status as a doctoral student and no assurance that he will be accepted as a doctoral candidate until he has passed a candidacy examination. This examination is administered by the major department and is given early in the student's program.

GENERAL REQUIREMENTS—No specified number of courses completed or credits earned will assure attainment of the doctorate. The general requirements are based upon a period of residence, the writing of a satisfactory thesis, and the passing of a comprehensive and a final oral examination. A doctoral program consists of such a combination of courses, seminars, and individual study and research as meets the minimum requirements of the Graduate School and is approved by the doctoral committee for each individual student.

A master's degree is not a prerequisite for the doctorate. However, the first year of graduate study leading to the Ph.D. may be substantially the same as that provided for the M.A. or M.S. degree. Similarly the first year of the D.Ed. program may be essentially the same as that provided for the M.Ed.

GRADE-POINT AVERAGE—A minimum grade-point average of 3.00 for work done at the University is required for admission to the comprehensive examination and for graduation in the case of all candidates whose first registration for graduate study at the University occurred in the spring term 1964 or later.

TIME LIMITATION—A student who was formally accepted as a doctoral candidate on or after June 1, 1963, is required to complete his program within seven years from the date of his acceptance as a candidate. A student who was admitted to doctoral candidacy, formally or informally, prior to June 1, 1963, is required to complete his program before July 1, 1971.

OFF-CAMPUS AND TRANSFER CREDITS—Subject to the approval of his adviser and the head of his major department, a student may register for research to be done away from the University Park Campus.

With the approval of his committee, a candidate may apply toward the minimum requirements of a doctor's degree a maximum of 10 credits earned in Continuing Education classes or at the Commonwealth Campuses of The Pennsylvania State University. Credits so earned as a part of a master's degree program must be included in the limit of 10.

A maximum of 30 credits beyond the baccalaureate at an approved school not granting the doctorate in the student's major field may be accepted by the Graduate School in partial fulfillment of the requirements for a doctoral degree at The Pennsylvania State University. A maximum of two full academic years of work (60 credits) beyond the baccalaureate at a graduate school which grants the doctorate in the candidate's major field may be accepted here to apply toward doctoral degree requirements. Work beyond the master's will not be transferred if taken more than five years before beginning work for the doctorate at Penn State. Credits transferred will apply toward meeting degree requirements only if judged by the doctoral committee to be appropriate to the candidate's program of study.

ADVISERS AND DOCTORAL COMMITTEES—After a student has been admitted to a degree program, he should confer with the head of his major department con-

cerning departmental procedures and the appointment of an adviser. Arrangement and approval of the details of the student's term-by-term schedule is the function of the adviser. This person may be a member of the doctoral committee or someone else designated by the head of the major department for this specific duty.

General guidance of a doctoral candidate is the responsibility of a doctoral committee consisting of four or more members of the Graduate Faculty. One member shall be from outside the candidate's major field. It is appointed by the Dean of the Graduate School, upon recommendation of the head of the major department, after the student is admitted to candidacy. At his discretion, the Dean may add other members to the committee. The supervisor of the candidate's thesis will usually, but not necessarily, be designated as chairman. The chairman must hold senior membership in the Graduate Faculty. An associate member may not exclusively supervise the research for a doctoral candidate, but he may serve with a senior member as cochairman of a doctoral committee and/or as coadviser with a senior member, and thus may sign the title page of a thesis.

The doctoral committee is responsible for establishing the broad outline of the student's program and should review the program as soon as possible after his admission to candidacy. It will prepare, give, and evaluate the candidate's examinations, and supervise and approve his thesis. A favorable vote of at least two-thirds of the members of the committee is required for passing a comprehensive or a final oral examination. If a candidate fails an examination, it is the responsibility of the doctoral committee to determine whether he may take another examination.

The committee will also notify the Dean when the candidate is ready to have his comprehensive and his final oral examination scheduled and will report the results of these examinations to the Dean.

LANGUAGE AND COMMUNICATION COMPETENCE—A candidate for the degree of Doctor of Philosophy is required to demonstrate high-level competence in the use of the English language, including reading, writing, listening, and speaking. Proficiency is expected at the time of admission to the Graduate School and must be achieved before admission to candidacy.

In addition to demonstrating competence in English, each candidate for the Ph.D. must meet the language and communication requirement for foreign language(s) which has been established by his major department with the approval of a Graduate School advisory committee.

If a candidate is to be examined for a reading knowledge of a foreign language by one of the language departments, he must report his intention to take the examination to the secretary of the language department by the end of the first week of classes for the term during which he wishes to take it, except in the case of French or Spanish. This date is one week prior to the examination date. The examination will be administered on dates announced in the graduate calendar at the beginning of this bulletin.

Candidates for the D.Ed. degree may be required to demonstrate competency in foreign languages.

CANDIDACY EXAMINATION—This examination is administered by the major department and should be taken early in the student's program. For the Ph.D. student following the new requirements, the examination may be given after he has earned at least 12 credits in graduate courses beyond the baccalaureate. He must take the examination not later than three terms after earning 24 credits.

For all other Ph.D. and D.Ed. students, the examination should be given when the student has earned a total of approximately 30 credits, including his master's program and work done elsewhere. A student transferring from another graduate school with 30 or more transfer credits must be given the candidacy examination before he has earned more than 10 credits here.

COMPREHENSIVE EXAMINATION—When a candidate for the Ph.D. or D.Ed. degree has substantially completed his course work, he is required to take a comprehensive examination covering his major and minor fields of study.

A candidate for the Ph.D. must have satisfied the language and communication requirements before taking the examination.

All candidates whose first registration for graduate study at the University occurred in the spring term 1964 or later are required to have a minimum grade-point average of 3.00 for work done at the University at the time the comprehensive examination is given.

The examination is officially scheduled and announced by the Dean of the Graduate School upon recommendation of the doctoral committee. It is given and evaluated by the doctoral committee and may be *either written or oral, or both.* A favorable vote of at least two-thirds of the members of the committee is required for passing. In case of failure it is the responsibility of the doctoral committee to determine whether the candidate may take another examination. The results are reported to the Dean of the Graduate School, and will be entered on the candidate's official record.

When a period of more than five years has elapsed between the passing of the comprehensive examination and the completion of his program, the student is required to pass a second comprehensive examination before the final oral examination will be scheduled.

FINAL ORAL EXAMINATIONS—The doctoral candidate who has satisfied all other requirements for the degree will be scheduled by the Dean of the Graduate School, on recommendation of the doctoral committee, to take a final examination. Normally the final oral examination may not be scheduled until at least three months have elapsed after the comprehensive examination was passed, although the Graduate Dean may grant a waiver in the case of an outstanding student. The deadline for holding the examination is seven weeks before Commencement.

The final examination is oral, open to the public, and related in large part to the thesis; but it may cover the candidate's whole field of study without regard to courses that have been taken either here or elsewhere.

A favorable vote of at least two-thirds of the members of the committee is required for passing. The results of the examination are reported to the Dean of the Graduate School and will be entered upon the candidate's official record. If a candidate fails, it is the responsibility of the doctoral committee to determine whether he may take another examination.

Ph.D.—ADDITIONAL SPECIFIC REQUIREMENTS

The degree of Doctor of Philosophy is conferred in recognition of high attainment and productive scholarship in some special field of learning as evidenced by (1) the satisfactory completion of a prescribed period of study and investigation, (2) the preparation of a thesis involving independent research, and (3) the successful passing of examinations covering both the special subject and the general field of learning of which this subject forms a part.

In the fall term 1967 a revised set of requirements for the Ph.D. went into effect. A student who, by the end of the summer term 1967, had earned 45 or fewer graduate credits which were applicable toward his degree follows the new requirements.

RESIDENCE REQUIREMENTS—There is no required minimum of credits or terms of study, but over some twelve-month period during the interval between admission to candidacy and completion of the Ph.D. program the candidate must spend at least three terms (which may include the term in which the candidacy examination is

taken) as a registered student, during which time he is engaged in full-time academic work on the University Park Campus or at The Milton S. Hershey Medical Center *and* is certified by his department as devoting half time or more to graduate studies and/or thesis research to meet his degree requirements.

After a student has passed the comprehensive examination and met the three-term residence requirement, no further registration for credit will be required by the Graduate School. He shall, however, maintain his status as a student by registering continuously (at least three terms per calendar year) until the thesis is accepted by his doctoral committee. This registration may be for (1) courses for credit, for which the student will pay the regular per credit fee of $32 (in-state residency) and $75 (out-of-state residency), (2) noncredit, on-campus thesis preparation (601) using University facilities and/or faculty services, for which the student pays a special dissertation fee of $75, or (3) noncredit, off-campus thesis preparation (611) requiring little or no faculty services, for which the student pays a special dissertation fee of $25. Grades are not given for noncredit 601 or 611.

OLD RESIDENCE REQUIREMENTS—A student who had earned more than 45 credits by the end of the summer term 1967 will be required to span a minimum of nine terms in full-time graduate study and research (10 credits per term), or their equivalent in credits (90 credits), for the Ph.D. At least 30 credits must be earned in residence at the University Park Campus.

For a period of three terms, two of which must be consecutive, the Ph.D. candidate must limit his work load to half-time at most, the balance of his time being devoted to graduate study.

A graduate assistant or research assistant who is a candidate for the doctorate, has passed the comprehensive examination, is registered for the maximum allowable credit load, and is certified by his department as devoting all his time to studies and thesis research to meet his degree requirements may be regarded by the Dean of the Graduate School as a full-time student for a period not exceeding one calendar year. Such a student will be considered to earn the equivalent of 10 credits per term, and three such terms will meet the minimum residence requirement for the Ph.D.

MINOR FIELDS—A Ph.D. candidate is not required by the Graduate Faculty to have a minor field of study. However, a department or a committee in charge of a major field may require a candidate to offer work in a minor field, or a student may elect such a program with the permission of his doctoral committee.

A minor consists of no fewer than 15 credits, including those applied toward the master's degree, of integrated or articulated work in one field related to, but different from, that of the major. A minor program must meet the approval of the departments or committees responsible for both the major and the minor fields.

THESIS—The ability to do independent research and competence in scholarly exposition must be demonstrated by the preparation of a thesis on some topic related to the major subject. It should represent a significant contribution to knowledge, be presented in a scholarly manner, reveal an ability on the part of the candidate to do independent research of high quality, and indicate considerable experience in using a variety of research techniques. The contents and conclusions of the thesis must be defended at the time of the final oral examination.

The completed thesis, together with three separate copies of an abstract, must be filed in the office of the Dean of the Graduate School not later than five weeks prior to the commencement at which the candidate expects to receive the degree.

A Thesis Information Bulletin, which gives details concerning format, paper, illustrations, and other items, may be obtained at the Graduate School Office of Theses and Publications, 320 Graduate Building.

D.Ed.—ADDITIONAL SPECIFIC REQUIREMENTS

Programs leading to the degree of Doctor of Education are not limited to specific fields of education but, with the consent of the department or committee in charge, may also be offered in any other field appropriate to the preparation of teachers which has been approved for the doctorate, e.g., biological science, foods and nutrition, or English.

The degree is conferred in recognition of advanced preparation of a high order for work in the profession of education as evidenced by (1) satisfactory completion of a prescribed period of study; (2) ability to apply scientific principles in classroom instruction, supervision of instruction, administration, or as a consulting specialist in certain educational areas; (3) preparation of a thesis demonstrating ability to undertake an educational problem with originality and independent thought; and (4) successfully passing examinations, i.e., showing a satisfactory grasp of the field of specialization and its relation to allied educational areas.

RESIDENCE REQUIREMENTS—A minimum of nine terms of full-time graduate study and research (10 credits per term), or their equivalent in credits (90 credits)—of which at least 30 credits must be earned in residence at the University Park Campus or The Milton S. Hershey Medical Center—is required for the D.Ed. degree. The D.Ed. candidate may meet the requirements by attending summer terms unless his major department requires a period of registration in other terms or in consecutive terms at University Park. A candidate may register for a maximum of 30 credits of research in absentia, but none of these may count toward the minimum of 30 credits which he is required to earn on the University Park Campus or at The Milton S. Hershey Medical Center. It is expected that students will register for a minimum of 15 credits of thesis research. The maximum credit load permitted a student who is employed full time is 4 credits per term.

MAJOR AND MINOR FIELDS—The program of study includes a major and either a minor or a group of general studies. A majority of the courses offered in fulfillment of the requirements must be in the major field of study.

A candidate choosing a major outside the fields of education (such as speech, geography, or history) shall have a minor consisting of no fewer than 15 credits, including those applied toward the master's degree, in educational foundations, which includes courses in comparative education, educational measurements and statistics, educational psychology, history of education, and philosophy of education.

A candidate choosing a major in one of the fields of education must also choose either a minor or a group of general studies with the approval of the major department. In this case a minor consists of no fewer than 15 credits, including those applied toward the master's degree, in one field outside those of education. An acceptable general studies group consists of no fewer than 15 credits, including those applied toward the master's degree, in fields outside those of education considered by the major department to have significance and value for the candidate.

COMPREHENSIVE EXAMINATIONS— In addition to demonstrating a high level of competence in the subject matter of his major and minor fields, each candidate must show in his comprehensive examination that he is familiar with current theories of education; that he understands and can apply the techniques and the findings of educational research so far as they bear upon the teaching of his subject; that he is prepared to read understandingly and contribute to the technical and professional literature in his field; and that he can criticize his own procedures in the light of historical trends and practices in this and other countries. Command of the tools for a thorough study of the problems of education is necessary and must include familiarity with statistical methods. For certain students the requirements may include a reading knowledge of one or more foreign languages.

All candidates whose first registration for graduate study at the University occurred in the spring term 1964 or later are required to have a minimum grade point average of 3.00, for work done at the University, at the time the comprehensive examination is given.

THESIS—Evidence of a high degree of scholarship, competence in scholarly exposition, and ability to select, organize, and apply knowledge must be presented by the candidate in the form of a written thesis. The candidate must demonstrate a capacity for independent thought as well as ability and originality in the application of educational principles or in the development of new generalizations under scientific controls. A thesis may be based upon a product or project of a professional nature, provided scholarly research is involved. For example, it may be based upon the solution of a professional problem concerned with the development of a curriculum, or a product of creative effort related to education. However, in order to be acceptable as a thesis, the professional project must be accompanied by a written discourse demonstrating the nature of the research and including such theories, experiments, and other rational processes as were used in effecting the final result. The topic and outline of the proposed thesis must have the approval of the doctoral committee.

The completed thesis, together with three separate copies of an abstract, must be filed in the Office of the Dean of the Graduate School not later than five weeks prior to the commencement at which the candidate expects to receive the degree.

A Thesis Information Bulletin, which gives details concerning format, paper, illustrations, and other items, may be obtained at the Graduate School Office of Theses and Publications, 320 Graduate Building.

STUDENT AIDS

In every case in which a graduate assistantship, fellowship, grant-in-aid, or scholarship for the next academic year is offered to an actual or prospective graduate student, the student, if he indicates his acceptance before April 15, will have complete freedom through April 15 to submit in writing a resignation of his appointment in order to accept one elsewhere. However, an acceptance given or left in force after April 15 commits him not to accept another appointment without first obtaining formal release for the purpose.

STATEMENT OF NONDISCRIMINATION

In the selection of individuals for all types of financial aids for graduate study, in which the University has partial or complete control of the selection process and administration of the program, the University will not discriminate on the basis of race, creed, color, sex, or national origin of any applicant.

ASSISTANTSHIPS

Approximately 1,900 graduate assistantships are awarded annually. Most of these are half-time, but a limited number of quarter-time and three-quarter-time assistantships are available in some departments. An appointee may serve as an assistant in classroom or laboratory instruction, or in research or other work.

A prospective student should write directly to the head of his major department for information and application forms. Appointments are made upon the recommen-

dation of the department head, subject to the student's admission to the Graduate School. Clear evidence of superior ability and promise is required. Reappointment to an assistantship requires a continuing demonstration of good scholarship.

The assistantships vary as follows:

QUARTER-TIME—The student may schedule 7-9 credits, receives a stipend in the range $90-$190 per month plus a grant-in-aid which covers tuition, will be required to give a maximum of ten hours of service per week for twelve weeks, and will be considered to be following a full-time course of instruction under Selective Service regulations.

HALF-TIME—The student may schedule 5-7 credits, receives a stipend in the range $180-$380 per month plus a grant-in-aid which covers tuition, will be required to give a maximum of twenty hours of service per week for twelve weeks, and will be considered to be following a full-time course of instruction under Selective Service regulations.

THREE-QUARTER-TIME—The student may schedule 4-5 credits, receives a stipend in the range $270-$570 per month plus a grant-in-aid which covers tuition, will be required to give a maximum of thirty hours of service per week for twelve weeks, and will be considered a part-time student.

The credit load limits specified above may be increased or decreased for a specific term by arrangement with the Dean of the Graduate School, provided the credit load and the service load are properly balanced in each term and the total credit load over a series of terms is in conformity with the specified limits.

In addition to receiving a grant-in-aid to cover full tuition during the term of appointment, a graduate assistant who is completing three or more consecutive terms of service is entitled to apply for an extra earned grant-in-aid to cover tuition for the succeeding term without service if he is not receiving a scholarship or fellowship from another source during the term. To receive this privilege a student must obtain an extra earned grant-in-aid form from the head of the department in which he has held the assistantship and must follow the instructions on the form in making application.

A graduate assistant may not accept employment, either at the University or elsewhere, during the period for which service to the University is required under the appointment (twelve weeks per term).

A graduate assistant pays no fee for the privilege of driving and parking on the campus but is required to comply with student regulations concerning motor vehicles.

FELLOWSHIPS AND TRAINEESHIPS

More than eight hundred fellowships and traineeships are awarded annually. Recipients must be superior students and are frequently required to have completed a certain minimum of graduate work before being eligible for an award. Fellows and trainees carry full-time graduate programs, receive stipends which vary with the awards, and usually receive grants-in-aid paid by the donors of the awards to provide for all tuition. They may not accept employment during the terms of their appointments (except when stipulated for training purposes), nor are they required to render any service to the University. In some cases a recipient will be expected to limit his research to a broad field specified by the donor. Recipients are required to pay specific charges, such as admission, late registration, change of schedule, and parking fees, and also the thesis binding and microfilming fee unless the latter is paid for by the donor of the award.

GRADUATE SCHOOL FELLOWSHIPS—A small number of fellowships, each paying a stipend of up to $2,520 for the fall, winter, and spring terms and providing a grant-in-aid to cover all tuition charges for these terms, are given by the University and are designated as Graduate School Fellowships. They are available to outstanding graduate students working toward a doctorate degree in any field, although, ability of applicants being comparable, some preference is given to students majoring in the humanities and social sciences.

Applications should be addressed to the Graduate School Fellowship Office, 317 Graduate Building, and must be received by February 8 to be considered for the following year.

GRADUATE SCHOOL SCIENCE FELLOWSHIPS—A small number of fellowships each paying $260 per month plus a grant-in-aid of tuition are available to incoming graduate students in science fields. Application procedures are the same as for Graduate School Fellowships.

FELLOWSHIPS AND TRAINEESHIPS FROM SPECIFIC GRANTS TO DEPARTMENTS AND DIVISIONS BY FOUNDATIONS, INDUSTRIES, AND FEDERAL AGENCIES—At least 230 such awards, with various stipends are granted through individual departments. Information and application forms may be secured from the head of the major department concerned. The specific awards will vary somewhat from year to year, but the following are typical of those which were available for 1969-70.

Airco-Speer Carbon Fellowship—Available to a graduate student in fuel science for studies on carbon; stipend $2,680-$3,500.

Amelia Earhart Fellowship—Available to a woman graduate student in aerospace engineering; stipend $2,400.

American Chemical Society Fellowships (2)—Open to graduate students in geochemistry, mineralogy, and solid state science; stipend $2,400.

American Iron and Steel Institute Fellowships (2)—Open to graduate students in geochemistry and metallurgy; stipend $2,400-$4,320.

Armstrong Cork Summer Fellowships in Chemistry (5)—Open to graduate students in chemistry; stipend $750.

Atomic Energy Commission Graduate Traineeships in Nuclear Reactor Operations and Utilization (6)—Open to graduate students in nuclear engineering; stipends comparable to the AEC Special Fellowships.

Automotive Safety Foundation Fellowships—Open to engineering graduates for graduate study in highway traffic engineering. Only U. S. citizens are qualified. Fellowships include tuition and living stipend of $2,840 for the nine-month course starting each fall term.

Brockway Glass Company Fellowship—Available to graduate student in ceramic science whose thesis is in the area of glass science; stipend $3,500-$4,000.

Carborundum Corporation Fellowship—Available to a graduate student in mineral processing; stipend variable up to $3,600.

Chevron Oil Company—Western Division Fellowship in Geology or Geophysics —$2,000 plus tuition and fees, plus $600 dependency allowance for children.

Continental Oil Company Fellowship—Available to a graduate student in chemical engineering; stipend $2,700.

Continental Oil Company Fellowship—Available to a graduate student in petroleum and natural gas engineering for studies in petroleum engineering; stipend $2,280.

Continental Oil Company Fellowship in Petroleum Economics—Available to a graduate student in mineral economics for studies in petroleum economics; stipend $2,280.

Diamond Shamrock Corporation Fellowship—Available to a graduate student in chemical engineering; stipend $2,325.

DU PONT FELLOWSHIP—Available to a graduate student in mechanical engineering; stipend $900 per term plus tuition.

DU PONT SUMMER FELLOWSHIPS (6)—Open to graduate students in chemical engineering; stipend $600.

W. S. ELLIOTT FELLOWSHIP—Available to a graduate student who is a Penn State graduate and is interested in engineering research; stipend $1,200.

ENO FOUNDATION FOR TRANSPORTATION, INC. FELLOWSHIPS—Open to engineering graduates for graduate study in highway traffic engineering. Only U.S. citizens are qualified. Fellowships include tuition and living stipend of $2,840 for the nine-month course starting each fall term.

ERNST AND ERNST FELLOWSHIP—Available to a master's candidate in accounting; stipend $1,000.

FISHER-PRICE FELLOWSHIP—Available to an advanced graduate student in child development and family relationships and especially interested in work with young children; stipend $3,500 for tuition and other expenses.

GENERAL FOODS FUND FELLOWSHIPS (2)—Open to graduate students with a major in the College of Human Development; stipend for doctoral $3,000, for master's $2,000 for tuition and other expenses.

GULF OIL COMPANY FELLOWSHIP IN PETROLEUM AND NATURAL GAS ENGINEERING—Available to a graduate student for work in petroleum production; stipend $2,400.

GULF OIL CORPORATION FELLOWSHIP—Available to a graduate student in chemical engineering; stipend $2,500.

HASKINS AND SELLS FOUNDATION FELLOWSHIP—Available to a graduate student in accounting; stipend $2,500.

HILL FELLOWSHIPS FOR STUDY IN ANTHROPOLOGY OR HISTORY—Details available from Dean S. F. Paulson of the College of the Liberal Arts, 108 Sparks Building.

HILL FELLOWSHIPS IN HISTORY—Available to graduate students in history for the completion of the Ph.D. dissertation; nonrenewable; stipend $3,000.

H. R. IMBT SERVICES, INC., FELLOWSHIP—For graduate work in civil engineering in the field of civil engineering construction; stipend $3,000.

INTERNATIONAL LEAD ZINC RESEARCH ORGANIZATION FELLOWSHIP—In support of research on the application of lead and zinc compounds to chemical, ceramic, electrical, and allied industries. Available to two students in ceramic science; stipend $3,000.

INTERNATIONAL LEAD ZINC RESEARCH ORGANIZATION FELLOWSHIP—In support of research on the physics and chemistry of lead and zinc compounds. Available to a student in solid state science; stipend $2,540.

JOSEPH M. JOHNSTON MEMORIAL SCHOLARSHIP—Available to a student whose program is related to floriculture; stipend variable.

MARATHON OIL COMPANY FELLOWSHIP—Available to a graduate student in petroleum and natural gas engineering; stipend $2,280.

NATIONAL LEAD COMPANY, TITANIUM ALLOY MANUFACTURING DIVISION FELLOWSHIP—In support of research on the chemistry and physics of titanium and zirconium compounds of interest to the chemical and ceramic industries; stipend $2,800.

NATIONAL STEEL CORPORATION FELLOWSHIP—Available to a graduate student in metallurgy; stipend $2,880.

NORTON COMPANY FELLOWSHIP—Available to a graduate student in ceramic science for research on thermal/mechanical properties; stipend $3,000.

EDWARD ORTON, JR., CERAMIC FOUNDATION FELLOWSHIP—Available to a student in ceramic science for studies relating to kiln-dried ceramic materials; stipend $2,400.

OWENS-ILLINOIS FELLOWSHIP—Available to graduate student in ceramic science whose thesis is in the area of glass science and technology; stipend $3,000-$3,600.

PENNSYLVANIA COOPERATIVE FISHERY UNIT FELLOWSHIPS (3-4)—Open to graduate students in zoology; stipend $2,400-$2,460.

Pennsylvania Environmental Engineering and Science Fellowships—Available to graduate students in environmental studies; $5,400 for stipends, plus tuition and related fees.

Pennsylvania Natural Gas Men's Fellowship—Available to a graduate student in petroleum and natural gas engineering for studies in gas technology; stipend $2,000.

Price Waterhouse Foundation Fellowship—Available to a Ph.D. candidate in accounting; stipend variable up to $5,000.

Proctor and Gamble Company Fellowship—Available to a U.S. citizen who is a beginning graduate student in chemical engineering; stipend $2,700.

Radio Corporation of America Fellowship—Available to a graduate student in electrical engineering; stipend $2,100-$3,000 for nine months. May be supplemented for an additional three months on application.

Refractories Institute—research in field of refractories. Available to student in ceramic science; stipend $3,000.

Rockwell Manufacturing Company Fellowship—Available to a graduate student in mechanical engineering; stipend $900 per term plus tuition.

Shubert Fellowship in Playwriting—Available to a graduate student in theatre arts; stipend $2,500.

Edwin Earle Sparks Dissertation Fellowship in the Humanities (1)—Available to doctoral candidate in the humanities (classics, English, French, German, history, philosophy, religious studies, Slavic languages; Spanish, Italian, and Portuguese; speech); stipend $3,500 plus tuition. Apply to relevant department before February 1.

Edwin Earle Sparks Fellowships in the Humanities (8)—Available to beginning graduate students in the humanities (classics; English, French, German; history; philosophy; religious studies; Slavic languages; Spanish, Italian, and Portuguese; and speech); stipends $2,400 plus tuition. Apply to relevant department before February 1.

Stackpole Carbon Fellowship—Available to a graduate student in fuel science for studies on carbon; stipend $3,600.

Stackpole Ferrite Fellowship—Available to a graduate student in ceramic science or solid state science; stipend $3,000.

Sun Oil Company Fellowship in Chemistry—Available to the incoming graduate student who is judged to offer the greatest promise for a successful career in chemistry; stipend $3,000.

Surface Combustion Fellowship—Available to a graduate student in fuel science for studies in the field of gaseous combustion; stipend $3,600.

Texaco Fellowship in Environmental Studies—Available to a graduate student in environmental studies; stipend $3,000 per year plus tuition.

Union Carbide Fellowship—Available to a graduate student in mechanical engineering; stipend $2,700 per year (three terms) plus tuition.

Union Carbide Summer Fellowships (5)—Available to a graduate student in chemical engineering; stipend $780.

U.S. Environmental Protection Agency Water Quality Office Traineeships—Open to students in water quality control. Annual stipend $2,400 plus tuition and dependency allowances.

U.S. Office of Education Experienced Teacher Fellowships in Geography (15)—Open to secondary school teachers with at least one year of experience, preferably three years, who are released from their school systems and promise to return after the year's study; stipend $4,000 plus dependency allowance.

U.S. Office of Education Fellowships—Open to graduate students with undergraduate degree in engineering, physical science, or mathematics who are preparing for technology teachers in technical institutes and junior colleges; stipend $2,400 for 12 months plus an allowance of $500 for each dependent.

U.S. Office of Education Fellowships in Education of Exceptional Children (28)—Open to graduate students being prepared as leadership personnel in the education of the mentally retarded and the emotionally disturbed and in special

education administration; stipend $2,200-$3,200 plus dependency allowance. Apply to the head of the Department of Special Education.

U.S. Office of Education Fellowships in Speech Pathology and Audiology: Work with the Speech-Handicapped (5); Work with the Deaf (4)—Open to graduate students specializing in these fields; stipend $2,200-$3,200 plus dependency allowance. Apply to the director of the Speech and Hearing Clinic.

U.S. Office of Education Prospective Teacher Fellowships in Family Life and Sex Education (6)—Open to master's degree students majoring in child development and family relationships and preparing for teaching family life and sex education in elementary or secondary schools; stipend $2,000-$2,200 plus dependency allowance.

U.S. Office of Education Traineeships in Educational Psychology (6)—Open to graduate students majoring in educational psychology and preparing for careers as educational research workers; stipend $2,400-$2,800 plus dependency allowance.

U.S. Public Health Service Air Pollution Special Fellowship (Post-Doctoral)—Available to post-doctoral scholars in the physical sciences, biological sciences, and social sciences; stipend $6,000-$7,000 plus dependency allowance.

U.S. Public Health Service Traineeships in Air Pollution (26)—Open to selected graduate students in the physical sciences, biological sciences, and social sciences; stipend $3,000-$3,600 plus dependency allowance. Applications and information available through the Center for Air Environment Studies.

U.S. Public Health Service Traineeships in Clinical Psychology (18) Open to selected graduate students in this area of psychology; stipend $1,800-$3,000.

U.S. Public Health Service Traineeships in Microbiology (4)—Open to selected graduate students in microbiology; stipend $2,400-$2,800.

U.S. Public Health Service Traineeships in Social Gerontology (12)—Open to selected post-master's graduate students in the social and behavioral sciences; stipend $2,600-$2,800 plus dependency allowance. Apply to director, Program in Adult Development and Aging.

U.S. Public Health Service Traineeships in Verbal Behavior (6)—Open to selected graduate students in this area of psychology; stipend $2,000-$2,800.

U.S. Rehabilitation Services Administration Traineeships in Speech Pathology and Audiology (11)—Open to graduate students specializing in speech pathology and audiology; stipend $2,400-$3,400.

U.S. Rehabilitation Services Administration Traineeships in Therapeutic Recreation (6)—Open to graduate students specializing in therapeutic recreation; stipend $1,800 (three terms).

United States Steel Fellowship—Available to a graduate student in metallurgy; stipend $2,400-$3,600 per year.

U.S. Vocational Rehabilitation Administration Traineeships in Vocational Rehabilitation Counseling (36)—Open to graduate students in counselor education who are specializing in vocational rehabilitation counseling; stipend $1,800-$2,000.

Veterans Administration Internships in Clinical Psychology (5)—Open to selected advanced graduate students in this area of psychology; stipend $3,500-$6,500, not including tuition and fees.

Walter Thomas Memorial Scholarship—Available to a student studying the nutrition of horticultural crops; stipend variable.

In addition grants are available from governmental agencies, industrial concerns, foundations, and the armed forces for graduate study and frequently for support of investigations of particular problems. Some of these permit full-time study and carry the same exemptions as the fellowships listed above. Detailed information may be secured from departments.

Arthur Young and Company Fellowship (1)—Open to a master's degree candidate in accounting from a predominantly black college.

EXTERNALLY SPONSORED FELLOWSHIP AND TRAINEESHIP PROGRAMS—Attention is directed to the following national programs, involving numerous fields of study, with which the University cooperates by providing local administration. (See statement on nondiscrimination, p. 67.)

Atomic Energy Commission Special Fellowships in Nuclear Science and Engineering—These fellowships are available to United States citizens who hold bachelor's degrees in engineering or physical science (chemistry, earth science, mathematics, or physics) and who have completed mathematics through ordinary differential equations. Applicants for first-year fellowships will be required to take the Graduate Record Examinations, designed to test aptitude and achievement, which are administered in January at a large number of centers in the United States and overseas. Before a fellowship appointment becomes effective, the fellow must be granted fellowship clearance by the Atomic Energy Commission and must be accepted by a participating university for study leading to an advanced degree. The deadline for filing applications for fellowships beginning in September is the first of the preceding January. Forms may be obtained from the NSE Fellowship Office, Oak Ridge Associated Universities, Oak Ridge, Tennessee. About 200 will be awarded.

Housing and Urban Development Graduate Fellowships—For the graduate training of professional city planning and urban and housing technicians and specialists; carry stipends of $3,000 per year plus tuition plus $500 per dependent. About 100 are awarded annually in national competitions. Application forms are available from Urban Studies Fellowship Program, Community Development Training Divisions, U.S. Department of Housing and Urban Development, Washington, D. C., 20410, and must be completed and filed by April 15 for study starting the following September.

International University Fellowships in Space Science—These graduate and post-doctoral fellowships are available to foreign nationals who hold the equivalent of master of science or master of engineering degrees and meet graduate student entrance requirements at United States universities. Details on the program will be found in the brochure concerning these fellowships issued by the Office of Scientific Personnel, National Academy of Sciences, Washington, D. C.

National Aeronautics and Space Administration Traineeships in Aerospace Related Acoustics and Noise Control (6)—Open to outstanding graduate students in science and engineering preparing for careers in research; stipend $2,400-$3,400 per year plus tuition. Apply to head of department of major.

National Defense Graduate Fellowships—Under Title IV of the National Defense Education Act of 1958, as amended, the U.S. Commissioner of Education makes an allotment of three-year fellowships to approved institutions which have applied for them and designates the major fields among which the awards may be distributed. One purpose of these awards is to assist able graduate students who certify their interest in college or university teaching to obtain their doctorate, thus increasing the higher education teaching staff nationally. The program also aims to increase the development and utilization of doctoral degree training facilities and promote their wider distribution geographically.

Two-thirds of these fellowships in an institution must be awarded to students with no more than one-half year of graduate study by September; the remainder may be awarded to those who have completed no more than two years of graduate study by September. The University had 113 students studying under these fellowships in forty-four different fields of the arts and sciences in 1970-71.

No institution knows until the fall of each year whether it will have any additional fellowships under this program for the following year. Applications will be made directly on forms available from the Office of Graduate Fellowships, 317 Graduate Building, and are due on February 8 for appointments starting the following fall.

National Defense Modern Foreign Language Fellowships—Under Title VI of the National Defense Education Act of 1958, as amended, the U.S. Commissioner of Education allocates to institutions which have approved programs of study in certain languages of critical importance to the United States, and in the cultural areas related to these languages, graduate fellowships for the study of these languages and the related areas. The languages involved in this program are in general those not commonly taught in the United States. French, German, Italian, and Peninsular Spanish are excluded.

Applicants must give reasonable assurance that they will be available after graduate study for teaching a modern foreign language or a related study in a college in the United States or for such other public service as may be specified in the application materials.

In 1971-72 the University awarded three fellowships in Russian language and area studies for majors in Slavic languages, in the Eastern European program for students majoring in Russian, and for those majoring in economics, geography, history, or political science, with emphasis on Eastern Europe but also studying a Slavic language. Write to the head of the department of one of these four departments or to the head of the Department of Slavic Languages.

National Science Foundation Graduate Fellowships—The Graduate School cooperates in this program of prestige fellowships requiring outstanding credentials and available in the biological, engineering, mathematical, and physical sciences; anthropology; economics (excluding business administration); geography, history and philosophy of science; political science; psychology (excluding clinical); and sociology (excluding social work). Also included are interdisciplinary fields such as biophysics, geochemistry, meteorology, and physiology. These fellowships are used at the university of one's choice. Application is made during the fall to the Fellowship Office, National Academy of Sciences-National Research Council, 2101 Constitution Ave., N.W., Washington, D. C. 20418, which has charge of evaluating applicants for the Foundation. About 1,148 new awards were made for 1971-72. The application deadline for 1971-72 was November 30, 1970.

National Science Foundation Graduate Traineeships—This program was expanded in 1966-67 to include all the areas supported by the Graduate Fellowship Program mentioned above. The National Science Foundation awards training grants to various recognized universities to accelerate the output of graduate students in these fields and to help meet the nation's future needs for scientific and professional manpower. In 1971-72 the University had fifty-two of these traineeships distributed through thirty-four areas supported by NSF. Stipends are the same as for National Science Foundation Fellowships. Application forms are available from the Office of Graduate Fellowships, 317 Graduate Building, and are due on February 8 for appointments starting the following fall.

National Science Foundation Science Faculty Fellowships—These awards are made to enhance the effectiveness of college faculty members who have at least three years' experience as full-time staff members teaching science, mathematics, or engineering mainly to undergraduates. They are awarded to those working for a Ph.D. or to those holding the degree and teaching in any of the fields supported by the NSF Graduate Fellowship Program. Tenure may be from three to fifteen months and can be spread over three successive summers. For information, write to the National Science Foundation, Washington, D. C. 20550. The application deadline for 1970-71 was October 6, 1969; about 212 awards were made.

U.S. Public Health Service Predoctoral Fellowships—Available to graduate students in anatomy, anthropology, behavioral sciences, biochemistry, biomedical engineering, biophysical sciences, biostatistics, botany, developmental biology, endocrinology, entomology, genetics, history of life sciences, medicinal chemistry, micro-

biology, nursing, nutrition, organic chemistry, pathology, pharmacology, physiology, social and psychological sciences, zoology, and air and water pollution. These fellowships are used at the university of one's choice and are more frequently awarded to second- or third-year graduate students. Prior to formal application a senior must have been admitted to a graduate school and have obtained a sponsor there who will supervise his training. Application should be made to the Career Development Review Branch, Division of Research Grants, National Institutes of Health, Bethesda, Maryland 20014, by October 1 for awards announced in February, by January 2 for June awards, and by April 1 for September awards.

WOODROW WILSON DISSERTATION FELLOWSHIPS—Awarded by the Woodrow Wilson National Fellowship Foundation for graduate study at the institution of one's choice to outstanding students in the areas of the humanities and social sciences who expect to complete all requirements for their Ph.D. degrees within four years after starting graduate study. A student *may not apply* for these fellowships but must be nominated by a professor in his college. The stipend is $225 per month, plus tuition. An interested student should consult the dean or other official of his college, or write to the Woodrow Wilson National Fellowship Foundation, Box 642, Princeton, New Jersey.

WOODROW WILSON NATIONAL FELLOWSHIP—Awarded by the Woodrow Wilson National Fellowship Foundation for first-year graduate study at the institution of one's choice to outstanding students who show a clear preference for a career in college teaching, especially in the areas of the humanities and social sciences. Science and mathematics majors will be considered; but they must also apply for National Science Foundation Fellowships, and, if one is received, the applicant must accept it in preference to the Woodrow Wilson award. Each student must be nominated by a professor in his undergraduate college. The nomination is sent to the regional representative of the Woodrow Wilson Fellowships for the area in which that college is located. An interested student should consult the dean or other official of his college, or write to the Woodrow Wilson National Fellowship Foundation, Box 642, Princeton, N. J. Nominations must reach the regional chairman by October 31 each year. Three hundred awards were made for 1971-72.

OTHER AIDS

RESIDENT ASSISTANTSHIPS FOR MEN AND WOMEN—A number of appointments are available to graduate students to serve as resident assistants in the undergraduate residence halls. A resident assistant's responsibility is to work for the social, academic, and emotional adjustment of the undergraduate residents. Specialized training and experience in personnel work are helpful, although not essential. These appointments are for three terms (fall, winter, and spring). Remuneration is in the form of room, board, and full in-state tuition. A resident assistant may not hold a fellowship or an additional assistantship during the term of his appointment, nor may he engage in any other form of part-time employment. He may carry 7 to 9 credits per term. Requests for further information and application materials should be addressed to the Division of Residence Hall Programs, 117 Old Main, University Park, Pa. 16802.

GRADUATE RESIDENT ADVISER FOR MEN AND WOMEN—Positions as graduate resident adviser are available to both men and women. The positions are basically half-time, paying a stipend and allowing enrollment of 7 credits per term. Preference is given to persons working for a degree in higher education with specialization in student personnel administration or counselor education. Responsibilities include coordination of programming in one or two buildings of a residence community and various administrative and advising assignments. Those appointed are

expected to reside on campus. Further information and application materials are available from the Division of Residence Hall Programs, 117 Old Main, University Park, Pa. 16802.

GRADUATE TUITION GRANTS-IN-AID—Forty grants for full-time study are awarded each year on a term basis, providing for all tuition. They are available to any student on the basis of financial need and academic promise. A recipient is expected to carry a full program of graduate work but may accept employment with the University or another employer not to exceed ten hours per week, provided he reduces his academic load to 8 or 9 credits. Application for renewal of the grant-in-aid may be made for succeeding terms. The value of these grants to Pennsylvanians is $260 per term, and to non-Pennsylvanians, $600 per term. A few grants are available for students beginning graduate study in the winter or spring term, if applications are filed six weeks before registration for that term.

Applications should be addressed to the Office of Graduate School Fellowships, 317 Graduate Building, and must be received by March 1 to be considered for the following summer or fall.

PHI KAPPA PHI GRANTS-IN-AID—One or two tuition grants-in-aid in each of spring and summer terms are available for students completing degree requirements during the term of the award. Application procedures are the same as for Graduate Tuition Grants-In-Aid.

THE RUTH YOUNG BOUCKE GRADUATE FELLOWSHIP—Established from the estate of Ruth Young Boucke, whose husband was for many years a professor of economics, this fellowship is available every other year to an outstanding graduate student on the same basis as the regular Graduate School fellowships, and selection is made by the Graduate School Committee on Fellowships and Awards. The stipend is at least $1,800 for a tenure of three terms plus a grant-in-aid for tuition.

JOHN W. WHITE FELLOWSHIPS—Awarded to two or three graduates of The Pennsylvania State University each year on the basis of scholarship, need, character, and aptitude. The recipients may enroll in any approved college or university. Application is made to the Office of Student Aid, 121 Grange Building.

SCHOLARSHIPS—A number of scholarships furnished by outside agencies and organizations are awarded annually through individual departments. A request for information should be directed to the department head in the field of the student's major interest.

LUCRETIA V. T. SIMMONS SCHOLARSHIP—The State College Chapter of the American Association of University Women has established a modest scholarship which is awarded annually to honor an outstanding woman graduate student. The award does not include exemption from tuition. Nominations are made by departments.

LOANS ADMINISTERED BY THE UNIVERSITY—The Director of the Office of Student Aid has charge of all loans administered by the University, for both undergraduate and graduate students. Application forms may be obtained from his office in 121 Grange Building. Funds are available from three sources:

University Loan Funds have been established through the generosity of University organizations, alumni, faculty, staff, and friends. Graduate students without assistantships who are registered for full credit loads may obtain long-term loans, while graduate assistants who are classified as full-time students by the Dean of the Graduate School may qualify only for short-term loans from these funds. Applicants must demonstrate a need for financial assistance in meeting University-related expenses and be United States citizens, except that international students may qualify for short-term loans if they can secure a responsible resident of Pennsylvania as cosigner

of the note. The interest on long-term loans does not begin until after graduation and generally is at a low rate for the first two years.

National Defense Education Act Loan Funds are available for United States citizens from the federal government, this act having been expanded in the fall of 1964 to increase the amount allotted to each institution and to increase the ceiling on loans to graduate students to $2,500 per year. The forgiveness of half the loan over a five-year period for those entering teaching has been extended to college teaching and to teaching in private elementary and secondary schools, as well as to teaching in public elementary and secondary schools. Interest at 3 per cent does not start until nine months after the borrower ceases to be a full-time student. Repayment must then be made at the rate of no less than $15 per month.

The Alumni Graduate Student Loan Fund has been established through the efforts of the University Alumni Fund and contributions of Graduate School alumni who have received their bachelor's degrees elsewhere. The Graduate Student Association has also made sizable contributions to it. The purpose of this fund is to assist graduate students on a short-term loan basis in meeting somewhat unexpected financial obligations associated with receiving a degree, such as thesis typing, thesis binding and microfilming fee, job interview travel, etc. Students who have completed all required credits and are not registered, but are completing their theses and anticipating graduation at the next commencement, may qualify for these loans.

STATE HIGHER EDUCATION LOAN PLANS—A number of states have passed laws which enable them to set up agencies to guarantee loan agreements with commercial banks, enabling cooperating banks in those states to make long-term personal loans to qualifying students to help pay their college or graduate school expenses. This cooperation makes possible lower interest charges and longer repayment periods than are available for ordinary personal loans.

Pennsylvania has established the Pennsylvania Higher Education Assistance Agency for those who have been residents of Pennsylvania for one year prior to filing applications and are accepted for enrollment in approved institutions of higher education. A full-time graduate student may borrow up to $1,500 per year, the total not to exceed $7,500 during the entire period of his post-secondary education. To be eligible, a part-time graduate student must be enrolled for at least 6 credits and is limited to $500 per year. The federal government will generally pay the interest on behalf of the student while he/she is enrolled in school and the first 3 per cent of interest while the student is making repayment following graduation or withdrawal from school. Repayment of the principal of the loan is not required until the student leaves or graduates from school. Generally, to be eligible for the interest subsidy, the annual adjusted family income must be below $15,000 per year and the student must be enrolled in an eligible course of study in a nonprofit institution. A list of participating lending institutions is available from all secondary school counselors, school financial aid officers, or the Pennsylvania Higher Education Assistance Agency, Guarantee Loan Program, Towne House, Harrisburg, Pennsylvania 17102.

Residents of other states should inquire of their state education departments regarding the existence of similar plans. Practically all the states of the United States, and the District of Columbia, have such programs.

GIRARD EDU-CHECK PLAN—The University offers to sponsors (including parents) of students the Assured Education Plan, enabling them to pay out of current income, on a monthly basis, University bills for tuition, residence hall room and board, and all other items billed by the University. Life insurance and total and permanent disability insurance are a part of the plan for the sponsor up to his sixty-eighth and sixty-first birthdays, respectively. Payments are handled through the Girard Bank, 2nd and Chestnut Streets, Philadelphia, Pa. 19106. Further information and application forms may be obtained from the Office of the University Bursar, 103

Shields Building. Signed agreements should be received well in advance of registration, since it takes at least three weeks for completion of arrangements.

STUDENT EMPLOYMENT—Many students depend upon part-time employment to help meet their expenses. A student who is thus employed, however, must recognize the time demands of his work schedule and will be required to adjust his academic load accordingly.

A student who holds a graduate assistantship, fellowship, or traineeship may not accept employment, either at the University or elsewhere, during the period of his appointment, except when stipulated for training purposes in certain fellowship and traineeship programs.

The Office of Student Aid, 121 Grange Building, offers assistance to students in finding part-time employment in town as well as on the campus. The State College Chamber of Commerce also gives assistance to students concerning part-time employment. The Chamber of Commerce, local placement services, and the University Personnel Office maintain files of positions open to wives of students. Many local residents seek help for baby sitting, housework, typing, and other general kinds of employment.

VETERANS' BENEFITS—The Coordinator of Veterans Affairs has the responsibility of handling all applications for benefits under the various Public Laws.

Under P. L. 89-358, a student is classified as full-time if he registers for 8 or more credits.

After each term's registration, the number of credits scheduled must be reported to the University Coordinator of Veterans Affairs for enrollment certification to the Veterans Administration.

Recently discharged servicemen not in this area may obtain information on veterans' educational benefits under P. L. 89-358 and its recent revision from the Veterans Administration representatives at their local county courthouses.

PROGRAMS AND COURSES

Programs of study leading to advanced degrees are offered in many major and minor fields. These are listed in the following section, and the major fields are summarized at the beginning of the following section. Related courses are grouped together under the name of the field. To locate a particular course or group of courses, consult the index.

In general, departments of the University are identified with specific major fields. Thus aerospace engineering is a major field of study which is offered under the supervision of the Department of Aerospace Engineering. On the other hand, engineering acoustics and comparative literature are major fields for which there are no corresponding departments. In such cases a committee of the Graduate School is responsible for administering the program. In some cases a single department offers work in more than one field. Thus the Department of Material Sciences offers work in ceramic science, fuel science, metallurgy, and solid state science.

Applicants for admission are encouraged to consult the person whose name is listed under the major field heading.

DEGREES—In those major fields approved for the doctorate, the Ph.D. is normally conferred, although a program leading to the D.Ed. may also be arranged with the consent of the department or committee in charge if such a professional program is appropriate. Similarly, in major fields approved for the master's degree the M.A. or M.S. is normally conferred, but a program leading to the M.Adm., M.Agr., M.B.A., M.Ed., M.Eng., M.E.P.C., M.F., M.F.A., M.P.A., or M.R.P. may also be available. The D.Ed. and M.Ed. are not limited to the fields of education but, with the consent

of the department or committee in charge, may be offered in any approved major field appropriate to the preparation of teachers, such as mathematics or English. In this case the program is sponsored by a major department outside the fields of education, such as the Department of Mathematics, but the student's minor is in education.

MINOR FIELDS—All major fields listed are also acceptable as minors, subject to the approval of the proposed minor department. In addition, a few fields in which no advanced degrees are offered have been approved as minors for candidates who are majoring in related areas. Such minor fields are identified in the summary at the beginning of the following section and by a brief statement under the field heading in that section.

A candidate's choice of minor field depends upon the particular degree he is seeking and is subject to the approval of both his major and minor departments. The requirements in each minor field are established by the minor department subject to the regulations of the Graduate Faculty.

INTERDISCIPLINARY MAJORS—In addition to the majors listed on the following pages, interdisciplinary majors involving two or more departments may be arranged with the approval of the Dean of the Graduate School. These programs are offered under the supervision of appropriate interdepartmental committees.

OTHER FIELDS—Fields which have not been approved for either major or minor work, but in which approved courses are offered, are listed at the end of this bulletin. These courses may be used in graduate programs as electives or as part of a general studies program, subject to the approval of the major department and to the restrictions upon the use of 400-series courses in degree programs.

COURSE NUMBERING SYSTEM—Courses in the series 1-399 are not listed in this bulletin because they are strictly undergraduate and yield no graduate credit. A graduate student may register for or audit these courses in order to make up deficiencies or fill in gaps in his earlier education but not to meet requirements for an advanced degree.

Courses in the series 400-499 are for upperclassmen with at least junior standing and for graduate students. Only a limited number of credits earned in these courses may be counted toward the requirements for an advanced degree. Detailed regulations concerning the restrictions are given on pages 55-61 under the specific requirements for the various master's degrees.

Courses in the series 500-599 are restricted to students registered in the Graduate School, seniors with an average of at least 3.50, and other students who have been granted permission to enroll by the Dean of the Graduate School.

The numbers 601 and 611 do not denote courses but are used for noncredit registration by a Ph.D. candidate who is following the new regulations which went into effect in fall term 1967. Registration under these numbers will maintain his status as a student during the interval which begins at the time he has both passed the comprehensive examination and met the three-term, full-time academic requirement and ends at the time his doctoral committee accepts the thesis. The student will register for 601 if he will be using University facilities and/or faculty services; he will register for 611 if he will be off-campus and requiring little or no faculty service. Candidates for the Ph.D. degree do not receive grades for noncredit registrations (601 and 611).

CREDITS—A credit is defined as a unit of time approximately equivalent to one week of full-time graduate study. Accordingly, a full-time student having no concurrent employment may earn a maximum of 10 credits in a ten-week term. A "credit" as used in this bulletin, therefore, is identical in meaning with a "semester credit" and should not be confused with a "quarter credit," which is associated with the traditional quarter system. By increasing the length of class periods to seventy-five

minutes, the Penn State calendar based upon a ten-week term provides for the same amount of time in a given course as does the typical semester plan.

COURSE DESCRIPTIONS—A course abbreviation, a number, and a title designate each course. Course designations and official abbreviations are listed in the left-hand margin just above the first course in each group. The figures in parentheses following the course title show the number of credits which may be granted for that course. In the case of courses with variable credits, the number of credits which may be earned in a single term is determined by the department offering the course.

A department may schedule an entire section of a course below the 400 level for fewer credits than the maximum authorized. In 400- and 500-series courses a department may schedule an individual student for fewer credits than the maximum number but in no case for more than the maximum number authorized.

SCHEDULE OF COURSES—A complete list of the courses which will be offered in any specific term is given in the *Schedule of Classes,* which is available at nominal cost from the Scheduling Office approximately four months before the beginning of the term. It gives the number of credits being offered in each course, the hours at which the class will meet, the location of the class, and in some cases the instructor's name.

RESEARCH AND THESIS WORK—In registering for thesis work a student uses the appropriate number (600, 601, 610, or 611) preceded by the abbreviation designating his major field. Thus, ENGL 600 denotes thesis research in English being done on the University Park Campus and ENGL 610 thesis research in English being done off-campus.

The numbers 601 and 611 are available only to Ph.D. candidates who are following the new regulations, have passed the comprehensive examination, and have met the three-term, full-time academic requirement. Such a candidate in engineering mechanics will register for E MCH 601 if he will be using University facilities and/or faculty services or for E MCH 611 if he will be off-campus and requiring little or no faculty service.

It should be assumed that 600 and 610 are available in all graduate major fields and that 601 and 611 are available in all fields approved for the Ph.D., although these numbers may not always appear in the *Schedule of Classes* for each term.

Major and Minor Fields

GRADUATE FIELDS OF STUDY

Administration—M.Adm.
Aerospace Engineering—Ph.D., M.S.
Agricultural Economics—Ph.D., M.S., M.Agr.
Agricultural Education—Ph.D., D.Ed., M.S., M.Ed.
Agricultural Engineering—Ph.D., M.S.
Agronomy—Ph.D., M.S., M.Agr.
Anatomy—Ph.D., M.S.
Animal Industry—Ph.D., M.S., M.Agr.
Animal Nutrition—Ph.D., M.S.
Anthropology—Ph.D., M.A.
Architectural Engineering—M.S.
Architecture—M.S.
Art—M.A., M.F.A.
Art Education—Ph.D., D.Ed., M.S., M.A., M.Ed.
Art History—Ph.D., M.A.
Astronomy—Ph.D.,M.S.
Biochemistry—Ph.D., M.S.
Biological Chemistry—Ph.D., M.S.
Biological Science—D.Ed., M.Ed.
Biology—Ph.D., M.S.
Biophysics—Ph.D., M.S.
Botany—Ph.D., M.S.
Business Administration—Ph.D., M.S., M.B.A.
Business Education—Ph.D., D.Ed., M.S., M.Ed.
Ceramic Science—Ph.D., M.S.
Chemical Engineering—Ph.D., M.S.
Chemistry—Ph.D., M.S.
*Child Development and Family Relationships
Civil Engineering—Ph.D., M.S., M.Eng.
Classics—M.A.
Comparative Literature—Ph.D., M.A.
Computer Science—Ph.D., M.S.
Counselor Education—Ph.D., D.Ed., M.S., M.Ed.
Dairy Science—Ph.D., M.S.
Developmental and Remedial Reading—M.Ed.
Earth Sciences—D.Ed., M.Ed.
Economics —Ph.D., M.A., M.Ed.
Education of Exceptional Children—Ph.D., D.Ed., M.S., M.Ed.
Educational Administration—Ph.D., D.Ed., M.S., M.Ed.
Educational Psychology—Ph.D., M.S.
Electrical Engineering—Ph.D., M.S.
Elementary Education—Ph.D., D.Ed., M.S., M.Ed.
Engineering Acoustics—Ph.D., M.S., M.Eng.
Engineering Mechanics—Ph.D., M.S., M.Eng.
Engineering Science—M.Eng.
English—Ph.D., D.Ed., M.A., M.Ed.
Entomology—Ph.D., M.S., M.Agr.
Environmental Pollution Control—M.S., M.Eng., M.E.P.C.
Extension Education—M.Agr., M.Ed.
*Family Economics and Home Management
Food Science—Ph.D., M.S.
Foods and Nutrition—Ph.D., D.Ed., M.S., M.Ed.
Forest Resources—Ph.D., M.S., M.F.
French—Ph.D., M.A.
Fuel Science—Ph.D., M.S.
General Engineering—M.Ed., M.Eng.
*General Family Studies
Genetics—Ph.D., M.S.
Geochemistry—Ph.D., M.S.
Geography—Ph.D., D.Ed., M.S., M.Ed.
Geology—Ph.D., M.S.
Geophysics—Ph.D., M.S.
German—Ph.D., M.A., M.Ed.
Higher Education—D.Ed., M.Ed.
History—Ph.D., D.Ed., M.A., M.Ed.
Home Economics Education—Ph.D., D.Ed., M.S., M.Ed.
Horticulture—Ph.D., M.S., M.Agr.
Human Development and Family Studies—Ph.D., D.Ed., M.S., M.Ed.
Humanities—M.A.
Industrial Arts Education—Ph.D., D.Ed., M.S., M.Ed.
Industrial Engineering—Ph.D., M.S., M.Eng.
Journalism—M.A.
Laboratory Animal Medicine—M.S.
Linguistics—Ph.D., M.A.
Man-Environment Relations—Ph.D., D.Ed., M.S., M.Ed.
Mathematics—Ph.D., D.Ed., M.A., M.Ed.
Mathematics (King of Prussia)—M.Ed.
Mechanical Engineering—Ph.D., M.S., M.Eng.
Medical Technology—M.S.
Metallurgy—Ph.D., M.S.
Meteorology—Ph.D., M.S.
Microbiology—Ph.D., M.S.
Microbiology (Hershey)—Ph.D., M.S.
Mineral Economics—Ph.D., M.S.
Mineral Engineering Management—M.Eng.
Mineral Processing—Ph.D., M.S.
Mineralogy and Petrology—Ph.D., M.S.
Mining Engineering—Ph.D., M.S.
Music—M.A., M.F.A.
Music Education—D.Ed., M.Ed.
Nuclear Engineering—Ph.D., M.S., M.Eng.
Nutrition in Public Health—M.S.
Petroleum and Natural Gas Engineering—Ph.D., M.S.
Pharmacology—Ph.D., M.S.
Philosophy—Ph.D., D.Ed., M.A., M.Ed.
Physical Education—Ph.D., D.Ed., M.S., M.Ed.
Physical Science—D.Ed., M.Ed.
Physics—Ph.D., D.Ed., M.S., M.Ed.
Physiology—Ph.D., M.S.
Plant Pathology—Ph.D., M.S.
Political Science—Ph.D., M.A.
Poultry Science—Ph.D., M.S.
Psychology—Ph.D., D.Ed., M.S.
Public Administration—M.P.A.
Recreation and Parks—M.S., M.Ed.
Regional Planning—M.R.P.
Religious Studies—Ph.D., M.A.
Rural Sociology—Ph.D., M.S., M.Agr.
Sanitary Engineering—M.S., M.Eng.
School Psychology—D.Ed., M.S., M.Ed.
Secondary Education—Ph.D., D.Ed., M.S., M.Ed.
Slavic Languages and Literatures—M.A.
Social Studies—M.Ed.
Sociology—Ph.D., M.A.
Solid State Science—Ph.D., M.S.
Spanish—Ph.D., D.Ed., M.A., M.Ed.
Speech—Ph.D., D.Ed., M.A., M.Ed.
Speech Pathology and Audiology—Ph.D., D.Ed., M.S., M.Ed.
Statistics—Ph.D., M.A., M.S.
Theatre Arts—M.A., M.F.A.
Veterinary Science—Ph.D., M.S.
Vocational Industrial Education—Ph.D., D.Ed., M.S., M.Ed.
Wildlife Management—M.S.
Zoology—Ph.D., M.S.

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*See Human Development and Family Studies

The degrees listed above are the ones normally conferred in each of the designated major fields. Additional professional degrees, including the M.Agr., M.Ed., and M.Eng., have been authorized in many cases and may be offered at the discretion of the department head and the Dean of the Graduate School. Thus, the M.Ed. has been authorized for all of the above fields in which a master's degree is conferred provided the field is appropriate to the preparation of teachers.

COURSES IN MAJOR AND MINOR FIELDS

ADMINISTRATION (ADMIN)

DANIEL M. POORE
Chairman, Graduate Programs in Administration at Capitol Campus
Middletown, Pa. 17057

Degree Conferred: M.Adm.

Graduate Faculty, Senior Members: Professors Lee and Saylor.

Graduate Faculty, Associate Members: Associate Professors Murty, Poore, and Woodruff.

This program is intended to meet the professional needs of practicing and potential administrators. All students must satisfy (1) a series of prerequisites for each option, (2) 15 credits of common core courses, and (3) at least 15 credits of option area course work. Options are currently available in Business Administration, Public Administration, and Engineering Administration. The Business Administration option is intended for those students who desire to pursue an administrative career in any phase of commerce, business, or industry. The Public Administration option is aimed at those students who desire to assume administrative responsibility in institutions, social work agencies, and local, state, or federal government. The Engineering Administration option is a quantitative program in management science and operations research.

The prerequisite requirements are an integral part of the program. Some or all of these requirements may be waived, based on equivalent work previously completed.

For Business Administration, prerequisite courses are required in micro- and macroeconomic analysis, current economic issues (Econ. 404), finite mathematics, calculus, probability and statistics, accounting, financial management, marketing management, and business law.

For Public Administration, prerequisite courses are required in micro- and macroeconomic analysis, current economic issues, finite mathematics, probability and statistics, and adequate preparation in the social sciences.

For Engineering Administration, prerequisite courses are required in micro- and macroeconomic analysis, current economic issues, finite mathematics, calculus, differential equations, linear algebra, probability and statistics, accounting and financial management, and graduation from an accredited undergraduate curriculum in engineering, mathematics, or physics.

For admission to the Master of Administration program, the student must have a baccalaureate degree from an accredited institution. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

The program is offered only at the Capitol Campus.

CORE COURSES

ADMIN. 500. ADMINISTRATIVE THEORY (3) History, significance and functions of administration, theories of leadership, authority, decision making, rationality, and efficiency.

ADMIN. 510. ORGANIZATION ANALYSIS (3) Examination of concepts of human behavior in formal organizations, systems analysis, conceptual models, and decision processes.

ADMINISTRATION

ADMIN. 530. RESEARCH ON ADMINISTRATIVE PROBLEMS (6) Studies in research design, analysis, and interpretation. Student independently conceptualizes, designs, and executes a comprehensive research project.

ADMIN. 540. ADMINISTRATIVE POLICY FORMULATION (3) Analysis of administrative problems from a total organization viewpoint. Case studies of actual organizations are used for analysis.

OPTION AREA COURSES*

In addition to the prerequisite and the common core requirements, each student must complete at least 15 credits of option area courses.

The following option area courses are available in 1971-72:

ACCTG. 511. INTERPRETATION OF ACCOUNT DATA (3)

FIN. 531. FINANCIAL MANAGEMENT (3)

MGMT. 510. OPERATIONS MANAGEMENT (3)

MKTG. 500. MARKETING MANAGEMENT (3)

ADMIN. 520. ADMINISTRATIVE MODELS (3) Formulation and solution of decision models for administrative problems. Analysis of decision making under certainty, risk, and uncertainty.

ADMIN. 550. PROGRAM PLANNING AND EVALUATION (3) Analysis and evaluation of public programs and systems from the perspectives of policy development and administrative planning and management.

ADMIN. 551. ADMINISTRATION AND THE POLITICAL PROCESS (3) Analysis of the relationship of administration to the political processes that shape public policy formulation and execution.

ADMIN. 560. SAMPLING THEORY AND PRACTICE (3) Study of scientific method of obtaining representative samples, collection of information, techniques of estimation. Prerequisite: Math. 315.

PL.SC. 575. GOVERNMENT MANPOWER MANAGEMENT (3)

PL.SC. 576. GOVERNMENT FISCAL DECISION MAKING (3)

I.E. 502. MANAGEMENT METHODS (3-6)

I.E. 508. OPERATIONS RESEARCH I (3)

I.E. 509. OPERATIONS RESEARCH II (3)

I.E. 510. MATHEMATICAL PROGRAMMING (3)

B.LOG. 504. PROBLEMS IN BUSINESS LOGISTICS (3)

AEROSPACE ENGINEERING (AERSP)

BARNES W. MCCORMICK, *Head of the Department*
233 Hammond Building

Degrees Conferred: Ph.D., M .S.

* Course descriptions not given below will be found under the designated field of study.

Graduate Faculty, Senior Members: Professors Holl, Lancaster, Lumley, McCormick and Sevik; Associate Professors Lakshminarayana and Tennekes; Assistant Professor Arndt.

Graduate Faculty, Associate Members: Associate Professors Eisenhuth and Sherman; Assistant Professors Allen, Kaplan, Phillips, and York.

Opportunities are available for graduate study in the following areas: low-speed aerodynamics, V/STOL aircraft, turbulence, geophysical fluid dynamics, astrodynamics, turbomachinery, plasma dynamics, rarefied gas dynamics, hydrodynamics, stability and control of aerospace vehicles, aeroelasticity, and aerospace structures.

The language and communications requirement for the Ph.D. degree may be satisfied by an intermediate knowledge of two foreign languages, by substitution of courses from other designated areas for one of these languages, or by a comprehensive knowledge of one foreign language.

The entering student must hold a bachelor's degree in physical science, mathematics, or engineering and may be required to complete (without degree credit) undergraduate course work in fluid and solid mechanics and intermediate mathematical analysis, if he has not already done so. Students with a 2.70 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.70 grade-point average may be made for students with special backgrounds, abilities, and interests.

AEROSPACE ENGINEERING (AERSP)

401a,b,c. Aerospace Engineering Projects (1-12)
405. Experimental Methods in Aerospace Engineering (3)
407. Aerodynamics of V/STOL Aircraft (3)
409. Advanced Aerospace Structural Mechanics (3)
410. Aerospace Propulsion (3)
411. Aeroelasticity (3)
412. Turbulent Flow (3)
413. Stability and Control of Aircraft and Missiles (3)
415. Physical Gas Dynamics (3-6)
416-417. Aerospace Design and Thesis (2 each)
420. Principles of Flight Testing (3)
421. (M.E. 421) Intermediate Viscous Flow (3)
425. Theory of Flight (3)
430. Space Propulsion and Power Systems (3)
450. Orbit and Attitude Control of Spacecraft (3)

503. Electromagnetically and Chemically Active Flows (3) Flow of media which may be conductive, permeable, ionizable, or otherwise capable of interacting with imposed or self-generated fields.

504. Aerodynamics of V/STOL Aircraft (3) Jet wings, high lift devices, propellers and ducted propellers, circulation and boundary layer control, unsteady airfoil theory. Prerequisite: Aersp. 407.

505. Aero- and Hydroelasticity (3) Interaction of elastic systems having several degrees of freedom with fluid flows in various configurations.

506. Cavitation (3) Flow regimes, dynamics of cavitation, prediction of the minimum pressure in the fluid, scale effects, effect of surface irregularities.

507. Theory and Design of Turbomachinery (3) Theory and principles of machinery design: compressors, turbines, pumps, and rotating propulsors; opportunity to work out design examples.

508. Perfect Fluid Theory A (3) Mathematical review, equations of motion and general consequences, application of complex variables to two-dimensional flow, conformal representatives, Stokes' steam function.

509. Perfect Fluid Theory B (3) Review of axisymmetric motion; two-dimensional vortex motions; motions with cylindrical, spherical geometry; Bessel, Legendre functions; vortex motions in space. Prerequisite: Aersp. 508.

510. Compressible Flow (3) One-dimensional motion, shock waves, flow in nozzles, two-dimensional flow, airfoil theory. Prandtl-Meyer flow, method of characteristics.

511. Aerodynamically Induced Noise (3) Review of fluid mechanics. General theory of aerodynamic sound. Noise radiation from jets, boundary layers, rotors and fans. Structural response. Prerequisite: Aersp. 412.

512. Viscous Flow (3) Stress-deformation relations; Newtonian fluids, Navier-Stokes equations; exact, asymptotic laminar solutions; instability, transition; similitude and turbulent boundary layer.

514. Stability of Laminar Flows (3) The stability of laminar motions in various geometries as influenced by boundary conditions and body forces of various kinds.

515. Foundations of Turbulence (3) The mathematics underlying turbulence theory: descriptions, kinematics of stochastic fields; techniques of solution of linear and some nonlinear problems.

516. Homogeneous Turbulence (3) Dynamics: production, spectral transfer, dissipation, decay of energy; similarity theories.

517. Inhomogeneous Turbulence (3) Dynamics: similarity, structural hypotheses; spatial, spectral budget of energy in a number of classical flows.

518. Aircraft and Missile Dynamics (3) Dynamical problems of aircraft and missiles including launch, trajectory, optimization, orbiting, re-entry, stability and control, and automatic control. Prerequisite: Aersp. 413.

520. Selected Topics in Aerospace Engineering (1-12)

AGRICULTURAL ECONOMICS (AG EC)

Lee M. Day
Head of the Department of Agricultural Economics and Rural Sociology
6A Weaver Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty, Senior Members: Professors Barr, Becker, Bennett, Brandow, Butz, Day, Frey, Hutton, McAlexander, Pasto, Pierce, Stemberger, and Trotter; Associate Professors Partenheimer and Gamble.

Graduate Faculty, Associate Members: Associate Professors Hallberg, Herrmann, Holt, Jansma, Madden, and Schutjer; Assistant Professor Epp.

The graduate program emphasizes economic theory and analytical techniques in the fields of farm management, production economics, agricultural marketing, resource economics, agricultural policy and prices, and in international agricultural trade and development.

The language and communications requirement for the Ph.D. degree may be satisfied by either (1) mastering one foreign language or (2) passing three graduate courses outside the major and minor fields having communications value.

The entering student in the master's program should have as prerequisites 3 credits in agricultural economics, 3 credits in economics, and 3 additional credits in either agricultural economics or economics. If a student lacks some of the prerequisites, he may take them without graduate credit during the early part of his master's program.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

AGRICULTURAL ECONOMICS (AG EC)

407. Advanced Farm Management (3) *Mr. Partenheimer*
410. Agricultural Finance and Appraisal (3) *Mr. Holt*
420. Agricultural Prices (3) *Mr. Bennett*
421. Land Economics (3) *Messrs. Frey and Gamble*
422. Land and Water Resource Policy (3) *Mr. Jansma*
450. International Agricultural Trade and Development (3) *Mr. Schutjer*
460. Industrial Organization in Food Processing and Distribution (3) *Mr. Brandow*
461. Decision Making in Agricultural Marketing Firms (3) *Mr. Stemberger*

500. Seminar in Agricultural Economics (1-6) Review of current literature and problems.

504. Seminar in Agricultural Policy (3) Analysis of farm prices, income consequences for producers and consumers, and effects on resource use; evaluation of policy, considerations in policy making. Prerequisites: Ag.Ec. 420, Econ. 405. Odd years. *Mr. Brandow*

505. Advanced Agricultural Statistics (3) Multiple correlation, curve fitting, analysis of variance, and other techniques applicable to the rural social sciences. Prerequisite: 3 credits in statistics. *Mr. Bennett*

507. Seminar in Farm Management (1-6) Special problems relating to organization and operation of the farm business. Prerequisites: Ag.Ec. 6, Econ. 14.

514. Survey Research Techniques in Agricultural Economics (3) Survey methods and design of samples for obtaining economic data from business-unit and household populations. Prerequisite: Ag. 400. Odd years. *Mr. Bennett*

515. Economic Problems in the Marketing of Dairy Products (3) Economic problems as they are encountered in the process of marketing; particular attention to governmental regulation in pricing and marketing. *Mr. Pierce*

520. Farm Price Analysis (3) Econometric analysis of prices, production, and utilization of farm products; review of research in this field. Prerequisites: Ag.Ec. 420, 505; Econ. 405. Even years. *Mr. Hallberg*

524. Resource Economics (3) Economic aspects of resource use and development: economic growth, land-use planning and control, conservation, resource investment criteria and policies. Prerequisite: Ag.Ec. 421 or 422. *Mr. Epp*

525. Research Methods in Rural Social Sciences (2) Scientific method in planning and conducting research. Prerequisite: 9 credits in social sciences.
Mr. John

527. Seminar in Applied Quantitative Methods (1-4)
Messrs. Hallberg and Partenheimer

534. Agricultural Production Economics (3) Economic theory applied to agricultural production problems: resource combinations, firm size, uncertainty and expectations, aggregate aspects of production, technological change.

535. Seminar in Agricultural Marketing (2)

550. Food Consumption Economics (3) Demand theory and research methods applied to the market for foods. *Mr. Herrmann*

571. Seminar in Land and Water Resource Economics (3) Critical review of research in resource economics; consideration of special topics in resource use.
Mr. Jansma

AGRICULTURAL EDUCATION (AG ED)

David R. McClay, *Head of the Department*
101 Agricultural Education Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors McClay and Stevens, Associate Professor Stinson.

Graduate Faculty, Associate Members: Professor Hoover, Associate Professor Anthony, Assistant Professor Curtis.

Graduate programs emphasize the professional improvement of teachers. They provide advanced preparation for employment in administration, supervision, teacher education, and research in agricultural education and related fields. A minor may be taken in an area of agricultural science, technology, business, or in general studies. Programs may include courses needed for certification in other fields of education.

The language and communications requirement for the Ph.D. degree may be satisfied by an intermediate knowledge of two foreign languages, by substitution of courses from other designated areas for one of these languages, or by a comprehensive knowledge of one foreign language.

Prerequisite to admission is a minimum of 18 credits in professional education courses or certification as a teacher of agriculture. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

AGRICULTURAL EDUCATION (AG ED)

400v. Educational Programs in Agriculture for Developing Countries (3)
418v. Survey of Vocational Education in Agriculture (1-4)
420v. Instructional Media in Agriculture (1-6)
422v. Supervision of Vocational Education in Agriculture (1-4)
424v. Occupational Guidance in Agricultural Industry (1-4)

426v. Adult Education in Agriculture (1-4)
434v. Agricultural Developments (1-6)

501v. Agricultural Education in the United States (1-3) Historical development, social and philosophical foundations, and current status in relation to the total vocational-technical education program.

502v. Teaching Agriculture (1-3) Vocational education objectives, learning theory, class instruction, cooperative occupational experience, and evaluation.

503v. Research in Agricultural Education (1-6 per term) Individual study problems in various phases of agricultural education, such as evaluation of teaching, teaching procedures, and teacher preparation.

504v. Agricultural Education Seminar (1 per term)

508v. Administration and Supervision of Agricultural Education (1-3) Administration of state and district systems of vocational-technical education; supervision of teachers of agriculture.

509v. Teacher Education in Agriculture (1-6) Organization and administration of university programs of teacher education in agriculture, including preservice preparation, continuing education, research, and other services.

520v. Scientific Method in the Study of Agricultural Education (1-4) Methods of procedure in investigation and experimentation in education, accompanied by a critical examination of studies made in agricultural education.

521v. Scientific Method in the Study of Agricultural Education (1-4) Continuation of Ag.Ed. 520v; emphasis upon statistical techniques for students' individual problems.

524v. Program Development in Agricultural Education (1-3) Analysis of occupational needs of students and employment prospects; organization of courses of study and other activities of teachers.

530. Agricultural College Teaching (3) Selection and organization of subject matter for specific courses, methods of learning, teaching devices, techniques of teaching, and measurements of results of teaching.

AGRICULTURAL ENGINEERING (AG E)

Frank W. Peikert, *Head of the Department*
250 Agricultural Engineering Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Aldrich, Mohsenin, and Peikert; Associate Professor Persson.

Graduate Faculty, Associate Members: Professors Bartlett, Myers, Schroeder, and Stephenson; Associate Professor Kjelgaard; Assistant Professor Morrow.

Graduate programs are available in the areas of physical properties of agricultural materials; plant and animal environmental engineering; agricultural processing and food engineering; agricultural mechanization with emphasis on forage, fruits, and vegetables; rural sanitation and conservation engineering; and computer technology applied to agricultural engineering problems.

The language and communications requirement for the Ph.D. degree may be satisfied by either (1) 9 credits of courses in humanities and social science or (2) a foreign language.

Excellent facilities, including equipment and instrumentation, are available for research in the designated areas. Among the special facilities are freeze-drying equipment for drying by sublimation, controlled environmental chambers, plant growth structures for modified atmosphere, a general purpose analog computer, and a laboratory for research on mechanical and rheological properties of agricultural materials. Laboratories are available with universal testing machines, equipped with accessories such as programmers and environmental chambers; a polariscope for photoelastic stress analysis; and acoustical and light reflectance instrumentation for research on the physical and rheological properties of agricultural materials.

Prerequisite to major work is the completion of an undergraduate major in engineering. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

AGRICULTURAL ENGINEERING (AG E)

400. Agricultural Engineering Problems (1-7)
401. Farm Mechanics for Teachers of Vocational Agriculture (1½-9)
402. Functional Design of Agricultural Structures (3)
403. Physical Properties of Agricultural Materials (3)
404. Agricultural Machinery (3)
405. Agricultural Process Engineering (3)
407. Soil Water Engineering (3)
408. Instrumentation for Agricultural Production and Processing (3)
409. Agricultural Systems Engineering (3)
410. Power for Agricultural Systems (3)
412. Physical Processes in Food Manufacturing I (3)
413. Physical Processes in Food Manufacturing II (3)
414. Physical Processes in Food Manufacturing III (3)
420. Seminar (1)
423. Physical and Rheological Measurements on Biomaterials (3)

500. Advanced Electro-Agriculture (1-6) Investigations in the application of electrical energy to processing, storing, and handling agricultural products. Seminar, written reports.

501. Advanced Farm Machinery (1-6) Application of agricultural engineering principles to design and operation of farm machinery. Prerequisite: Ag.E. 410.

502. Farm Structures Problems (1-6) Analysis of farm structures design problems.

503. Physical Properties of Plant and Animal Products (3) Physical characteristics; mechanical, rheological, thermal, electrical, and optical properties in relation to handling, storage, processing, and quality evaluation.

505. Experimental and Applied Instrumentation (4) The theory and application of electronics for instrumentation and experimental research.

507. Problems in Soil Water Engineering (1-6) Analysis of engineering problems relating to irrigation, drainage, or erosion control.

508. Advanced Problems in Farm Mechanics (1-15) Problems in farm shop practice and agricultural engineering related to the farm mechanics program of vocational education in agriculture. Prerequisites: Ag.E. 8, 14; or teaching experience in farm mechanics.

509. Research in Agricultural Engineering (1-4)

520. Agricultural Engineering Seminar (1-3) Reports on research and special topics.

AGRONOMY (AGRO)

James L. Starling, *Head of the Department*
117 Tyson Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty, Senior Members: Professors Baker, Duich, Fortmann, Hunter, Kardos, Matelski, McKee, Richer, Starling, Thomas, Washko, and Adjunct Professors Barnes, Jung, and Kendall; Associate Professors Cleveland, Cunningham, Harrington, Petersen, and Adjunct Associate Professors Heald and Marshall.

Graduate Faculty, Associate Members: Associate Professors Cole, L. J. Johnson, M. W. Johnson, Marriott, Pfeifer, Waddington, and Adjunct Associate Professor Hill; Assistant Professors Bollag, Hall, Ranney, and Risius.

Areas of specialization include soil chemistry; soil conservation; soil classification; soil fertility; soil mineralogy; soil physics; the genetics and breeding of corn, small grains, and forage plants; forage management; turf management; potato culture; tobacco culture; weed control; and ecology of crops and pastures.

The language and communications requirement for the Ph.D. degree is a reading knowledge of one foreign language, which may be met through courses or examination.

Prerequisites for major work in agronomy vary with the area of specialization, but basic courses in chemistry, mathematics, physics, and biological sciences are required. Students who lack some of the course prerequisites may be admitted but are required to take the prerequisite courses without degree credit.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

AGRONOMY (AGRO)

411. Breeding of Field Crops (3) — *Mr. Johnson*
415. Soil Morphology, Mapping, and Classification (3) — *Mr. Petersen*
416. Soil Genesis (3) — *Mr. Ranney*
417. Forest Soils (3) — *Mr. Ciolkosz*
419. Soil Properties (4) — *Mr. Baker*
422. Soil Conservation (3) — *Mr. Cunningham*
423. Pasture and Grassland Management (3) — *Mr. Washko*
424. Fertilizer Technology (3) — *Mr. Marriott*
425. Principles of Field Crop Production (3) — *Mr. Pfeifer*
431. Soil Fertility and Management (3) — *Mr. Marriott*

438. Principles of Weed Control (3) *Mr. Hartwig*
490. Agronomic Problems (1-6) *Mr. Washko and Staff*

501. Advanced Soil Fertility (4) Interpretation of fertility experiments and diagnosis of soil-plant relationships through field appraisal, analysis, and plant symptoms. Prerequisites: Agro. 431, Biol. 441. *Mr. Hunter*

503. Agronomy Seminar (1) Weekly meeting where papers and discussions will be presented by students and staff members.

506. Soil Chemistry (4) Analyses of important chemical and biochemical reactions occurring in soils, conditions which control these reactions and their importance in soil genesis and plant growth; laboratory work in the more typical and significant analytical procedures; lectures, review of current literature, and practicum. Prerequisites: Agro. 419; Bioch. 425 or Chem. 451. *Mr. Baker*

507. Soil Physics (4) Physical properties of the soil; factors affecting them; their measurements, evaluation, and influence in determination of soil productivity. Prerequisites: Agro. 419, Bioch. 425, Phys. 215. *Mr. Kardos*

509. Genetics of Crop Plants (3) Inheritance in crop plants with particular reference to factor interaction, genetic aspects of linkage and crossing-over, quantitative inheritance, and heterosis. Prerequisite: Biol. 422. *Mr. Cleveland*

510. The Application of Cytogenetics to Plant Breeding (3) Cytogenetics, including chromosome structure and behavior, chromosome alterations, polyploidy, interspecific hybridization, and their applications to plant breeding. Prerequisite: Biol. 422. *Mr. Cleveland*

512. Field Plot Technique (4) Ramifications of analysis of variance techniques; combining and analyzing data from several experiments; selection of valid error terms. Prerequisite: Stat. 200 or Ag. 400. *Mr. Risius*

516. Humus (2) Origin and chemical nature of soil organic matter, its importance in soil processes, and its decomposition. Prerequisites: Agro. 419, 431. *Mr. Richer*

517. Farm Crops Ecology (3) Ecological factors affecting growth and development of farm crops with particular reference to effects of altered environment and management practices. Prerequisites: Agro. 28, Biol. 441. *Mr. McKee*

518. Growth and Management of Forage Crops (3) Factors affecting growth and development of forage crops with particular reference to effects of environment, defoliation, and management practices. Prerequisites: Agro. 423, Biol. 441. *Mr. McKee*

519. The Nature of Soil Minerals (3) Modern methods for identification of the constituent minerals of soils and their relation to soil classification and agricultural practices. Prerequisites: Agro. 419, G.Sc. 23. *Mr. Johnson*

545. The Application of Statistics to Field Experiments (4) Use of advanced experimental designs in planning, analyzing, and interpreting experiments; includes lattice designs, factorials, confounding, simple and multiple covariance techniques. Prerequisite: Agro. 512. *Mr. Starling*

*550. Agronomic Problems (1-12) Provides training in selected areas of agronomy by means of supervised investigations or studies.

582. Seminar in the Breeding and Genetics of Farm Crops (1 per term)

* Credits 1-6 per term.

ANATOMY (ANAT)

BRYCE L. MUNGER, *Chairman of the Department*
The Milton S. Hershey Medical Center

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Baird and Munger, Associate Professors Ha and B. Pubols.

Graduate Faculty, Associate Members: Assistant Professor Wolfe, Mrs. L. Pubols.

The graduate program emphasizes the general areas of gross anatomy, histology/cytology, neuroanatomy/neurophysiology, or appropriate combinations of these areas. Approaches offered include morphological (descriptive, comparative, developmental), functional (physiological, chemical), and experimental. The language and communications requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

A bachelor's degree reflecting a reasonable background in zoology or biology, mathematics, and chemistry is required. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Applicants must provide complete transcripts and two letters of recommendation. Scores from the Graduate Record Examination and a personal interview are desirable.

This program is offered only at The Milton S. Hershey Medical Center.

ANATOMY (ANAT)

501. GROSS HUMAN ANATOMY (3) Macroscopic organization of the extremities and head and neck with emphasis on anatomical individuality, functional significance, and clinical correlations.

502. GROSS HUMAN ANATOMY (3) Macroscopic organization of the abdomen, thorax, and pelvis with emphasis on anatomical individuality, functional significance, and clinical correlations.

505. MICROSCOPIC ANATOMY (3) Microscopic organization of tissues and cells; interrelationships of cells; chemical and functional specializations of cells.

510. NEUROBIOLOGY (3) Morphology and function of the sense organs, general organization of the brain, and physiological studies of central nervous system function.

512. HUMAN EMBRYOLOGY (2) Detailed study of normal development and physiology of the embryo and fetus; attention to developmental anomalies and fertilization problems.

530. DISSECTION (2-4) Individual dissection of a particular region of the body, study of the pertinent literature, and preparation of a report.

535. SUBMICROSCOPIC ANATOMY (3) Current literature on molecular and micellar organization of cells and tissues in diverse systems; application of interference and electron microscopy.

540. SEMINAR (1 per term) Student and staff presentations designed to evaluate current research developments in anatomy.

542. Comparative Neurology (3) A study of comparative aspects of central nervous system organization as related to phylogenetic development. Prerequisite: Anat. 510.

543. The Peripheral Nervous System (3) A study of the somatic sensory and motor systems. Prerequisite: Anat. 510.

545. Comparative Vertebrate Otology (3) Evolution and principles of the auditory system demonstrated by comparison of structures in ears of vertebrates; independent study expected.

550. Seminar in Quantitative Optics (3) Study of the various types of light microscopy instruments and application of these tools to quantitative measurements in biological systems. Prerequisite: Anat. 505.

570. Special Topics (1-6) Introduction of students to the research laboratory and scholarly pursuits of members of the staff; credit arranged by consultation.

590. Research Problems (1-12) Individualized research conducted by students in departmental laboratories. The program and credits to be arranged by consultation.

ANIMAL INDUSTRY (A I)

B. R. Baumgardt
Head of the Department of Animal Science
325 Animal Industries Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty, Senior Members: Professor Baumgardt; Associate Professors Gobble, Sink, and Wilson.

Graduate Faculty, Associate Members: Associate Professors Merritt, Sherritt, and Ziegler.

A student may specialize in animal breeding, feeding, management, and meat science. The language and communications requirement for the Ph.D. degree may be satisfied by proficiency in either one foreign language or communications skills (technical writing and speech).

For admission the student must complete an undergraduate major in animal science or a closely related field. Students who lack some of the course prerequisites may be admitted but are required to take the prerequisite courses without degree credit. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

ANIMAL INDUSTRY (A I)

400. Special Topics (1-6)
405. Meat Animal Management (4)
421. Science of Meat (3)
423. Advanced Livestock Selection (2)
424. Animal Industry Seminar (1)
431. Advanced Meat Selection and Grading (2)

500. Seminar in Animal Industry (1-6)

501. Pedigree Study (1-6) Research work in breed study history, and analytical study of breed pedigrees, and a complete survey of the herd, flock, or stud book.

502. Research in Meats (1-6 per term) Investigation of methods for handling, cutting, processing, freezing, and curing meat and meat products. Prerequisite: A.I. 421.

503. Problems in the Animal Industry (1-6) Literature review, research methods, and current research in problems relating to the animal industry.

505. Advanced Animal Breeding (1-5) Special problems in animal genetics as applied to breeding and improvement of horses, cattle, sheep, and swine. Prerequisite: An.Sc. 322.

Note: *See Animal Science under "Other Elective Graduate Courses." Also see Food Science.*

ANIMAL NUTRITION (A NTR)

B. R. Baumgardt
Chairman of the Committee on Animal Nutrition
325 Animal Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Baumgardt, Buskirk, Cowan, Hartsook, Kesler, McCarthy, Mendez, and Mueller; Associate Professors Gobble, Hershberger, Leach, and Long.

Graduate Faculty, Associate Members: Assistant Professors Martin, Scholz, and Shellenberger.

This is an interdepartmental graduate program designed to enable students to obtain thorough training in animal nutrition. The program is under the direction of a committee composed of graduate faculty members of the departments of Animal Science, Dairy Science, Poultry Science, Veterinary Science, and the Human Performance Research Laboratory. Programs are offered in ruminant and nonruminant nutrition, including: physiology of nutrition; nutritional requirements for productive functions; metabolism of carbohydrates, lipids, proteins, vitamins, and minerals; and regulation of food intake and other metabolic functions.

The language and communications requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign languages.

Undergraduate preparation should include organic and analytical chemistry, physics, biology, and mathematics. Students may be admitted with limited deficiency, but are required to make up undergraduate deficiencies without graduate credit.

Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests.

The following nutrition courses are offered by participating departments, and their descriptions may be found under the listings of the respective departments: D.Sc. 511, Pty.Sc. 502. Courses related to animal nutrition can be found under the follow-

ing listings in this bulletin: Animal Industry, Biochemistry, Dairy Science, Foods and Nutrition, Physiology, Poultry Science, and Veterinary Science.

ANIMAL NUTRITION (A NTR)

400. Nutrition and Feed Technology (3)
401. Physiology of Nutrition (3)
402. Energy and Protein Metabolism (3)

505. Ruminology (3) Physiological, biochemical, and microbiological activities occurring within the rumen and the relation of rumen function to animal response. Prerequisites: at least one course in each of the following areas: animal nutrition, physiology, microbiology, and biochemistry.

Note: *See Animal Science listing under "Other Elective Graduate Courses."*

ANTHROPOLOGY (ANTHY)

Warren T. Morrill
Head of the Department
409 Social Sciences Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty, Senior Members: Professors Baker, Hunt, Matson, Morrill, and Sanders; Associate Professor Escobar.

Graduate Faculty, Associate Members: Associate Professor Michels, Assistant Professor Nydegger.

The master's program is designed to train students in general anthropology. The doctoral program is structured to train students in the following areas of specialization: new world archaeology, middle eastern archaeology, archaeological methodology, physical anthropology with special emphasis on human ecology, cultural ecology, comparative economics, personality and culture, oceanic ethnology, Latin American ethnology, sub-Saharan African ethnology, folk and peasant society.

The language and communications requirement for the Ph.D. degree includes a reading knowledge of a foreign language plus an option from among additional foreign languages, field languages, linguistics, and statistics.

Undergraduate preparation must include 12 credits in anthropology and archaeology or their equivalent and at least 6 credits in related sciences. A student with an excellent record but who does not meet these requirements may be admitted provided he makes up course deficiencies without graduate credit. Students with a 2.80 or above junior-senior average and with appropriate course backgrounds who have research interests directly related to the special anthropological competencies within the department will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests.

M.A. candidates may submit either a thesis or a term paper. If the latter is chosen, 6 additional credits in 500-level courses in the major field must be scheduled.

The M.A. degree may be bypassed by exceptional candidates for the Ph.D. degree.

ANTHROPOLOGY (ANTHY)

400. Human Evolution: the Material Evidence (3)

401. Human Evolution: Theory and Process (3)
402. Human Ecology (3)
403. Applied Physical Anthropology (3)
405. Primatology (3)
420. Archaeology of the Near East (3)
421. Archaeology of the Central Andes (3)
422. Archaeology of Meso-America (3)
423. Archaeology of Eastern United States (3)
440. Ethnology of South America (3)
443. Ethnology of the Old World (3-6)
444. Ethnology of Meso-America (3)
446. Ethnology of North America (3)
447. Ethnology of Sub-Saharan Africa (3)
449. Ethnology of Southeast Asia (3)
450. Comparative Social Organization (3)
451. Economic Anthropology (3)
453. (Soc. 453) Primitive Religion (3)
455. Culture and Personality (3)
456. Cultural Ecology (3)
457. Language in Culture (3)
460. Anthropological Theory (3)
461. Methods in Cultural Anthropology (3)
462. Methods in Archaeology (3)
463. Field Linguistics (3)
471. History of Anthropological Theory (3)

501. Evolution of Human Behavior (3) The application of evolutionary theory to the study of man's structure, function, and culture. Prerequisite: Anthy. 21 or 401, and 3 additional credits in anthropology, sociology, or psychology.

502-503. Ecological Theory in Anthropology (3 each) Man's biology, culture history, and culture variation from the ecological perspective. Two-term enrollment required. Prerequisite: 6 credits in anthropology.

504. Applied Anthropology (3) Methods and results of studies in which anthropological theory was applied to current problems in human biology and culture.

505. Naturalistic Behavior of Nonhuman Primates (3) Comparative study of behavior including taxonomy, geographic distribution, ecology, territoriality, population composition, grouping patterns, individual and group interactional characteristics, communication.

506. Cultural Dynamics (3) Survey of the major theories of culture change with special reference to archaeological research.

507. The Biology of Human Adaptability (3) An exploration of the biological mechanisms which aid man's survival in a variety of environmental settings.

508. Research Problems in Culture History (3-9)

509. Seminar in Regional Studies (3-9) Research and analysis in selected world cultural areas, including ecology, prehistory, history, ethnography, and current status.

510. World Ethnographic Survey (3) General survey of world cultures and their historical development.

530. Individual Readings in Anthropology (1-6) Reading or research in selected aspects of general anthropology.

531. Individual Research in Anthropology (3-6)

545. Seminar in Anthropology (1-9) Critical analysis of research in selected areas of anthropology.

560. Anthropological Theory (3) Theory used in culture-historical, sociological, and psychological interpretations.

561. Field Methods in Anthropology (3-9) Individual field work in any aspect of anthropology, supervised by staff of professional rank.

562. Laboratory Methods in Anthropology (3-9) Supervised laboratory research, utilizing materials from physical anthropology or archaeology or cultural anthropology.

563. Seminar in Linguistic Anthropology (3-6) Organized research on special topics in linguistic anthropology.

ARCHITECTURAL ENGINEERING (A E)

Gifford H. Albright, *Head of the Department*
101 Engineering A Building

Degree Conferred: M.S.

Graduate Faculty, Senior Members: Professor McLaughlin, Associate Professor Tichy.
Graduate Faculty, Associate Member: Professor Albright.

Students may specialize in structural analysis and design, environmental control engineering, illumination, acoustics, materials of construction, computer application to building design and performance, or nuclear defensive and protective construction. The latter area includes shelter planning, effects of nuclear weapons, shelter environmental requirements, analysis and design of blast-resistant structural systems, and integrated engineering requirement for protective construction.

For admission a student must have a strong background in some field of engineering; in engineering science or mechanics; or in architecture, psychology, economics, or management if there is adequate preparation in the physical sciences and mathematics. The detailed requirements depend upon the student's area of special interest.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

ARCHITECTURAL ENGINEERING (A E)

401. Architectural Engineering (3)
402. Architectural Engineering (3)
403. Architectural Engineering (3)
430. Architectural Engineering (3)
431. Architectural Engineering (3)
439. Architectural Engineering (3)
441. Integration of Architectural Engineering Systems (3)
442. Research in Architectural Engineering (1-6)
454. Environmental Engineering in Buildings—Design (3)
458. Advanced Architectural Acoustics and Noise Control (3)

464. Advanced Architectural Illumination Systems Design (3)
481. Architectural Engineering Thesis (2)
482. Architectural Engineering Thesis (2)
483. Architectural Engineering Thesis (2)
486. Professional Engineering Practice (3)

502. Architectural Engineering (3-8) Advanced structural design in steel and reinforced concrete. Lectures and class criticism. Practicum and seminar.

503. Architectural Engineering (4-8) Continuation of A.E. 502 in which problems of wind bracing in tall buildings, rigid frames, and heavy-framed constructions are studied. Practicum and seminar.

542. Advanced Problems and Research in Architectural Engineering (2-12) Investigation, analysis, and preparation of comprehensive report on subject relating to special problems in architectural engineering systems.

545. Architectural Engineering Seminar (1-6) Current literature and special problems in architectural engineering; presentation of technical papers.

551. Advanced Nuclear Defense Planning and Design I (3) Weapons effects data; dynamic strength of materials and structural elements; dynamic design; architectural, structural, electrical, and mechanical requirements for shelters. Prerequisites: A.E. 4, 5; E.Mch. 12.

552. Advanced Nuclear Defense Planning and Design II (3) Blast-resistant design of framed structures, shear wall structures, arches, domes, and underground structures; radiation shielding characteristics of building materials. Prerequisites: A.E. 431, 432, 551; Phys. 237.

553. Selected Problems in Nuclear Defense Research (1-6)

ARCHITECTURE (ARCH)

Raniero Corbelletti, *Head of the Department*
308 Sackett Building

Degree Conferred: M.S.

Graduate Faculty, Senior Members: Professors Corbelletti and Golany.
Graduate Faculty, Associate Member: Professor Hallock.

Advanced studies are offered in architecture, urban design, and planning. The student is offered opportunity for independent research and extensive interdisciplinary work under the guidance of specialists and scholars in technical, cultural, industrial, and social fields.

For admission, a five-year bachelor's degree program in architecture is required.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

ARCHITECTURE (ARCH)

408-409-410. Applied Architectural Design (5 each)

420. Architectural Research (1-12)
441. Architectural Design Analysis (3)
442. Architectural Design Analysis (3)
443. Architectural Design Analysis (3)
464. Architectural Systems—Comparative Analysis of Structure (1)
475. Architectural Systems—Environmental Control (2)

501. Architectural Design (4-8) Problems in advanced planning and design, including study of group composition. Practicum and seminar.

502. Architectural Research (2-12) Prosecution of assigned problems under the guidance of an instructor.

ART (ART)

Wirth V. McCoy, *Head of the Department*
210 Arts Building

Degrees Conferred: M.A., M.F.A.

Graduate Faculty, Senior Member: Professor McCoy.
Graduate Faculty, Associate Members: Professors Altman, Shobaken, and Zoretich; Associate Professors Adams, Cook, and Frost.

The M.A. program is planned to provide a broad range of experience and study in the visual arts. A thesis in an area of specialization is required. Requirements for admission include a broad undergraduate training in art and the presentation of a portfolio or examples of the student's work.

The M.F.A. program is planned to provide professional emphasis in a specific area of art. A creative project and supporting monograph are required. Requirements for admission include 24 credits in studio art with some indication of concentration in a chosen area and a statement of purpose concerning the professional aims of the candidate. A portfolio, photographs, or examples of the student's work must be presented.

All students accepted for graduate study in art who lack the adequate undergraduate courses or show deficiencies in some area will be required to take additional course work without degree credit.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

ART (ART)

411. Seminar in Art (3)
412. Individual Instruction (3)
*425. Advanced Drawing (3)
*430. Advanced Sculpture (3)
*448. Advanced Printmaking (3)
*450. Advanced Painting (3)
*460. Advanced Watercolor (3)
470. Graphic Design II (3)
471. Graphic Design III (3)
472. Exhibition Concepts and Structure (3)

* May be repeated for a total of 12 credits.

473. Seminar in Design Research (3)
*480. Advanced Ceramics (3)
*495. Advanced Photography (3)

501. Art Research (2-6) Original study and practice in art relating to material, concept, or technique.

530. Advanced Sculpture (3-12) Individual projects in sculpture leading to the development of a collection or body of work representative of the artist.

545. Printmaking (2-12) Problems in printmaking leading to the development of a collection or body of work representative of the individual artist.

550. Painting (2-12) Individual problems in painting leading to the development of a collection or body of work representative of the artist.

570. Design (2-12) Individual projects in design with special emphasis on professional practice in specialized fields of graphic design.

580. Ceramics (2-12) Experimental problems in ceramics leading to the development of a collection or body of work representative of the individual.

ART EDUCATION (A ED)

Harlan E. Hoffa, *Head of the Department*
269 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.A., M.Ed.

Graduate Faculty, Senior Members: Professors Beittel and Hoffa, Associate Professor Edmonston.

Graduate Faculty, Associate Members: Professors Chomicky and Schwartz, Associate Professors Bradley and Stewart.

Graduate programs in this field prepare students for careers in public school art teaching, art supervision, college teaching, administration, or research. To be admitted without deficiencies, the student is expected to have completed either a baccalaureate program in art education or a program leading to certification. Such a program would include work in art studio, art history, art education, education, educational psychology, and psychology. Deficiencies may be made up by course work which is not counted as credit toward an advanced degree.

All students are expected to complete two years of teaching before receiving the doctor's degree. Students seeking the Ph.D. degree must satisfy one of four language and communications skills requirements. These options include foreign languages, statistics, computer science, historiography, logic, or philosophical method.

Students with a 2.75 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.75 grade-point average may be made for students with special backgrounds, abilities, and interests. Transcripts should indicate high attainment in appropriate academic and creative work, and recommendations should attest to scholarship and ability to work independently. Creative work, as shown by slides and photographs, should show a high level of involvement and sensitivity to aesthetic forming processes.

* May be repeated for a total of 12 credits.

ART EDUCATION

Students who seek admission to the graduate program must make formal application to the Admissions Committee of the Department of Art Education.

ART EDUCATION (A ED)

404. Methods of Graphics and Illustrations (3)
414. Advanced Crafts for Teachers (3-6)
420. Ceramics for Teachers (3)
434. Art Appreciation in the Educational Program (3)
435. Art in the Elementary School (3)
436. Art in the Secondary School (3)
486. Current Problems in Art Education (2-3)
487. Mural Painting in Schools (3)
488. Advanced Mural Painting in Schools (3)
489. Art Experiences with Children (3)
490. Introduction to Research in Art Education (3)

501. Seminar in Art Education (1-6) The analysis of fundamental concepts derived from related disciplines; the examination of current problems; current literature.

504. Advanced Method in Graphic Processes (3) Exploration through laboratory experience of printing method: etching, silk screen, linoleum, or other; applications in teaching.

514. Functional Relationships in Crafts (3) Relationships of material design and purpose in crafts discussed by means of outstanding products of different materials, periods, and cultures. Prerequisite: 6 credits in crafts or 3 in design and 3 in advanced crafts.

516. Analysis of Three-Dimensional Processes in Art (3) Three-dimensional processes analyzed with regard to kinetic, textural, form, and other functions.

520. Advanced Ceramic Art (3) Intensified exploration of throwing, glazing, and firing processes as related to aesthetic considerations in contemporary art forms and past cultures. Prerequisite: A.Ed. 420.

535. Administration and Supervision of Art Education Programs (3) The problems and responsibilities of the city, county, and state art supervisor; curriculum, facilities, financing, supervision, in-service training, and reporting. Prerequisites: A.Ed. 435, 436.

536. Curriculum Development in Art Education (3) Factors affecting art curriculum decisions, analysis, selection, organization, preparation of curriculum. Evaluation and sources of art curriculum improvement and innovation. Prerequisite: 6 credits of methods.

588. History of Art Education (3) Historical development of philosophies in art education in the United States and abroad.

590. Research Methods in Art Education (3-6) Orientation in research methods; findings and designs related to the study of problems in art education.

597. Research in Art Education (1-6) Independent research, under an adviser, to be terminated by a scholarly report proportionately comparable in quality to a master's thesis. Prerequisite: 15 credits in art education on the 400 and 500 levels, including A.Ed. 598.

ART HISTORY (ART H)

WINSTON R. WEISMAN, *Head of the Department*
229 Arts Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty, Senior Members: Professors Battisti, Hyslop, van der Meulen, and Weisman; Associate Professor Cutler.

Graduate Faculty, Associate Member: Associate Professors Kiang and Mauner.

Graduate work is offered in the following areas: modern, Renaissance and Baroque, medieval, Byzantine, and ancient. Special research opportunities are available through the Center for the Study of Renaissance and Baroque Art.

Candidates for the M.A. are required to complete a master's thesis and to demonstrate a reading knowledge of at least one foreign language, or comprehensive knowledge of one. Candidates for the Ph.D. degree must pass a written comprehensive examination upon completion of their course work and, usually, before beginning the thesis. The language and communications requirement for the Ph.D. degree may be satisfied by a reading knowledge of two foreign languages, normally German, and either French or Italian. Other languages may be substituted with the approval of the adviser.

For admission a minimum of 18 credits in art history is required. Lacking these, a promising candidate may be accepted on condition that he make up the deficiency without graduate degree credit. Students with a 3.00 junior-senior average and with strong backgrounds in courses related to the major will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

ART HISTORY (ART H)

400. STUDIES IN ART HISTORY (3-6 per term)
401. STUDIES IN GREEK ART (3)
402. THE ILLUMINATED MANUSCRIPT (3)
405. PIONEERS OF MODERN ARCHITECTURE (3-6)
410. TASTE AND CRITICISM IN ART (3)
411. ART OF IMPERIAL ROME (3)
412. THE GOTHIC CATHEDRAL (3)
414. STUDIES IN ITALIAN BAROQUE ART (3-9)
415. THE SKYSCRAPER (3)
416. AMERICAN PAINTING: 1876-1913 (3)
422. STUDIES IN MEDIEVAL SCULPTURE (3)
423. STUDIES IN ITALIAN RENAISSANCE ART (3-9)
424. MASTERS OF NORTHERN BAROQUE ART (3)
425. MOVEMENTS IN NINETEENTH CENTURY ART (3)
432. PROBLEMS IN ICONOLOGY (3)
435. MOVEMENTS IN TWENTIETH CENTURY ART (3-6)

500. METHODS OF RESEARCH (3-6) Methods of art-historical research with emphasis on bibliographic and photographic resources.

510. STUDIES IN ART HISTORY (3-6 per term) Original investigation in art history, to be pursued independently or concurrently with course work in particular fields.

511. SEMINAR IN ANCIENT ART (3-12) Selected topics from the history of Greek and Roman art.

512. Seminar in Medieval Art (3-12) Original research into problems dealing with the art of the Middle Ages.

513. Seminar in Renaissance Art (3-12) Investigations in the area of Renaissance art, centering around major masters and monuments.

514. Seminar in Baroque Art (3-12) Investigations in the area of Baroque art centering around major masters and monuments.

515. Seminar in Modern Art (3-12) Lectures, readings, reports, and discussions in the field of modern art.

517. Seminar in Eighteenth Century Art (3-12) Investigation into themes and problems dealing with eighteenth century art.

522. Seminar in Byzantine Art (3-12) Specific iconographical and stylistic problems in Byzantine art and its relation to classical antiquity, the medieval West, and Islam.

525. Seminar in Modern Architecture (3-12) Investigation into the works and problems of modern architecture as they relate to the culture of our times.

590. Art History Field Seminar (3-12) Investigations based on on-the-site study of specific art objects, with trips in successive years to different art centers.

ASTRONOMY (ASTRO)

John P. Hagen, *Head of the Department*
103 Whitmore Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Hagen, Matsushima, and Sampson.
Graduate Faculty, Associate Members: Associate Professors Bauer and Zabriskie, Assistant Professors Usher and Winkler.

Opportunities are available to prepare for research or teaching. The principal research facilities of the department are in radio astronomy, but work can be done in meteors, astrophysics, and in various phases of theoretical astronomy. Modern astronomy has very close ties with mathematics, physics, and engineering. The program required of a doctoral candidate would normally include courses in at least two of these related fields, in addition to those in astronomy.

The language and communications requirement for the Ph.D. degree may be satisfied by a knowledge of computer programming which may be substituted for one of the two foreign languages required.

A bachelor's degree in astronomy, physics, mathematics, or electrical engineering is required for admission. Opportunity to make up possible undergraduate deficiencies is provided.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

ASTRONOMY (ASTRO)

430. General Astronomy for Teachers (3)

460. Fundamentals of Celestial Mechanics (3)
470. Solar Physics (3)
490-491. Introduction to Astrophysics (3 each)
492. Space Astronomy (3)
495. Practical Astronomy (3)

510. Astrophysics (3) An introduction to astrophysics in which the relevant physics, spectra, gas laws, plasmas, and radiation transfer theory are discussed.

511. Astrophysics (3) Stellar atmospheres; considerable emphasis is placed on the sun and on solar-terrestrial relationships. Prerequisite: Astro. 510.

512. Astrophysics (3) Stellar interiors, stellar evolution, pulsating stars, novae and supernovae; some discussions of the interstellar medium and gaseous nebulae. Prerequisite: Astro. 510.

513. Observational Techniques in Astronomy (3) Radiation quantities in theory and as observed. Astrometry, photometry, spectroscopy, stellar classification, interferometric methods. Observational laboratory. Prerequisite: Astro. 511.

516. Nonequilibrium Radiative Transfer Theory (3) Detailed study of theory of radiative transfer when the assumption of local thermodynamic equilibrium is not made, with astrophysical applications. Prerequisite: Astro. 511 or Phys. 561.

520. Galactic Structure (3) Stellar clusters and associations, galactic dynamics, stellar populations, distance determinations, luminosity calibration, and stellar statistics.

522. Spherical Astronomy (3) Astronomical coordinate systems, Kepler's equation, aberration, parallax, precession and nutation, time, eclipses and occultations, and solar motion.

523. Observational Theory (3) Information theory of noisy signals, statistics of nonlinear functions, theory and application of convolutions, selection effects, systematic errors, selected problems. Prerequisite: Astro. 513.

525. Double Stars (3) Two-body theory; analysis of visual, astrometric, spectroscopic, and eclipsing binaries; and discussions of particular systems. Prerequisite: Astro. 522.

530. Theory of Stellar Atmospheres (3) Theory of photospheric structure, radiative processes, and line-formation in the outer layers of stars, and interpretation of stellar spectra. Prerequisite: Astro. 511.

534. Stellar Structure and Evolution (3) A detailed study of the theory of the interiors and evolution of stars. Prerequisite: Astro. 511 or Phys. 561.

542. Gaseous Nebulae and Interstellar Matter (3) Theory and observations of galactic nebulae and interstellar medium, and problems related to the formation of stars and galactic structure. Prerequisite: Astro. 511.

545. Astrophysical Plasma Kinetic Theory (3) Kinetic theories, fluid behavior, collective phenomena, and collisional processes of plasmas and self-gravitating systems of gas and stars. Prerequisite: Phys. 530.

560-561. General Relativity and Cosmological Models (3 each) Riemannian geometry; general relativity theory and experiments; massive bodies; and Newtonian, Einsteinian, and steady state cosmologies are studied. Prerequisite: Phys. 525.

582. Radio Astronomy (3) Radiometers and antennas; signals in noise; solar physics; quiet and active solar radiation; transfer equation and solar radiation; solar-terrestrial effects. Prerequisite: E.E. 438 or Phys. 467.

583. Radio Astronomy (3) Radio astronomical studies of the moon and planets, galactic and extragalactic sources, and the structure of galaxies using line spectra. Prerequisite: Astro. 582.

590. Special Topics (1-3 per term) Theoretical studies in any field of modern astronomy or astrophysics, with or without associated experimental work. Prerequisites: Astro. 510, 511, 512.

BIOCHEMISTRY (BIOCH)

John H. Pazur, *Head of the Department*
109 Frear Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Clagett, Mallette, Pazur, and Shigley; Associate Professors McCarl, Phillips, and R. Schraer.

Graduate Faculty, Associate Members: Assistant Professors Aronson, Hammerstedt, Niehaus, and Winter.

Opportunities for research and graduate study are available in intermediary metabolism, cellular control mechanisms, molecular genetics, enzyme structure, nucleic acids, proteins, carbohydrates, lipids, photosynthesis, and endocrinology.

The foreign language and communications requirement for the Ph.D. degree may be satisfied by a reading knowledge of two foreign languages.

Entering graduate students should have had at least one year's work in each of the following: general chemistry, analytical chemistry, organic chemistry, physical chemistry, and general physics. Mathematics through integral calculus is also required. Students with limited deficiencies in these subjects may be admitted but must make up such deficiencies concurrently with their graduate studies. Undergraduate courses in biology, biochemistry, and foreign languages will be helpful to the student but are not required for admission.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

BIOCHEMISTRY (BIOCH)

401. General Biochemistry (3)
402. General Biochemistry (3)
403. Experimental Biochemistry (3)
417. Biochemical Methods (4)
425. Introductory Physical Biochemistry (4)
437. Physiological Biochemistry (3)
438. Physiological Methods (2)
439. Independent Study (1-12)

501. Enzymes and Biocatalysis (2) Enzyme kinetics, mechanisms of enzymic catalysis, correlation of structure and function, regulation of catalytic activity, literature reports. Prerequisite: Bioch. 402.

503. Biochemical Problems (1-10 per term) Prosecution of an assigned problem under the guidance of an instructor.

507. Seminar in Biochemistry (1 per term)

510. Proteins (2) Biochemical and physical properties of proteins and polypeptides, isolation and purification techniques, sequence analysis, conformational structure. Prerequisite: Bioch. 402.

511. Carbohydrates (2) Stereochemistry, conformational analysis, and chemical reactivity of carbohydrates; biochemistry of monomeric and macromolecular carbohydrates. Prerequisite: Bioch. 402.

512. Lipids (2) The structure, biosynthesis and metabolism of fatty acids, glycerides, phospholipids and sterols. Prerequisite: Bioch. 402.

515. The Biosynthesis of Macromolecules (2) An enzymological approach to the biosynthesis of DNA, RNA, proteins, complex polysaccharides and membranes. Prerequisite: Bioch. 402.

519. Topics in Metabolism (2) Selected topics dealing with metabolism and metabolic control, literature reports; may be repeated once in successive years. Prerequisite: Bioch. 402.

520. Biochemical Methods (3) Lectures and advanced laboratory on current techniques pertaining particularly to research on proteins and enzymes. Prerequisite or concurrent: Bioch. 501, 510.

521. Biochemical Methods (3) Lectures and advanced laboratory on current techniques pertaining particularly to research on lipids and carbohydrates. Prerequisite or concurrent: Bioch. 511, 512.

530. Contemporary Topics in Biochemistry and Molecular Biology (2-4) Lectures and discussions by visiting lecturers on new and significant developments in biochemistry and molecular biology.

BIOLOGICAL CHEMISTRY (BCHEM)

Louis F. Hass
In Charge of Graduate Programs in Biological Chemistry
The Milton S. Hershey Medical Center

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professor Davidson, Associate Professors Hass and Rosenberg.

Graduate Faculty, Associate Members: Assistant Professors Hill, Miljkovic, and Murray.

Opportunities for research and graduate study are available in the chemistry and metabolism of complex polysaccharides, cellular differentiation, mechanism of enzymatic reactions, biochemical genetics, biochemistry of complex lipids, conformational analysis of carbohydrates and proteins, natural product chemistry, and physical chemistry of macromolecules.

The language and communications requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. Interested students should contact the Director of Graduate Programs.

Research and graduate study opportunities are also available in the Department of Biochemistry at University Park. Course listings may be found on pages 106 and 107.

BIOLOGICAL CHEMISTRY (BCHEM)

502. Biological Chemistry (5) Principles of biological chemistry with emphasis on the relationship of macromolecular structure to function in metabolic pathways and specialized tissues.

503. Biological Chemistry of Nucleic Acids (2) Detailed discussion of nucleic acid biochemistry and its relation to genetic phenomena, especially organization, mutation, and segregation of genetic material.

513. Biological Chemistry Macromolecules (3) Methods of detailed determination of the three-dimensional structure of macromolecules, primarily enzymes and amino acid sequence and conformation of protein.

523. Metabolism (3) Molecular mechanisms employed by living systems to transform biological compounds, control production and utilization of energy, and regulate metabolic pathways.

540. Seminar (1 per term) Critical discussion of current literature within a facet of biochemistry; experimental design, procedures, and interpretation of results to be emphasized.

551. Kinetics and Mechanism of Enzyme Action (3) Current kinetic theory, rapid reactions, regulatory enzymes, chemical and physical approaches to the study of the mechanism of enzyme action. Prerequisite: B.Chem. 502. Concurrent: B.Chem. 523.

553. Biochemical Techniques (3) Lectures and discussion on approaches to macromolecule separation and characterization, isolation of sub-cellular organelles and specialized procedures for tissue fractionation. Prerequisite: B.Chem. 502.

570. Special Topics (2) Discrete areas of contemporary research in conformational analysis and natural product structure, complex polysaccharide structure, neurochemistry, and biochemistry of disease.

590. Research Problems (1-12) Individualized research on biochemical problems conducted by students in departmental laboratories.

BIOLOGICAL SCIENCE (BI SC)

Anton J. Kovar, *Chairman of the Committee on Biological Science*
309 Buckhout Laboratory

Degrees Conferred: D.Ed., M.Ed.

Graduate Faculty, Senior Members: Professors Anthony, Cheng, Cooper, Fergus, Grun, Hale, Hillson, Kovar, and Wright; Associate Professors Bellis, Hamilton, Hymer, Pursell, and Wickersham.

Graduate Faculty, Associate Members: Associate Professors Witham and Wood, Assistant Professor Neff.

The M.Ed. program in biological science is designed primarily to meet the needs of secondary school science teachers. The academic degrees M.S. and Ph.D. are not offered in biological science but are available in biochemistry, biophysics, botany, entomology, genetics, microbiology, physiology, plant pathology, and zoology.

The candidate for the M.Ed. degree must earn at least 21 credits in the natural sciences with a minimum of 15 credits in the biological sciences, including at least 6 in the animal sciences and 6 in the plant sciences. In addition, at least 6 credits in educational foundations and a term paper are required.

The D.Ed. program is designed for secondary school and college science teachers. Major course requirements are designated by the candidate's committee with the concept that teachers of biology have a broad background in biological disciplines and related fields. A minimum of 15 credits each is required in professional education and in thesis research. The requirement of a foreign language is at the discretion of the candidate's committee.

In order to enter a program for a higher degree with a major in biological science, the candidate should present 30 credits in the natural sciences, including one year of organic chemistry and one year of physics. A limited number of undergraduate deficiencies may be made up in pursuit of the advanced degree. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

BIOLOGY (BIOL)

Joseph G. O'Mara, *Head of the Department*
208 Life Sciences I Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Anthony, Cheng, Cooper, Dalton, Fergus, Grove, Grun, Hale, Hillson, Kneebone, Kovar, O'Mara, Schein, Spackman, Traverse, and Wright; Associate Professors Bellis, Butler, Dunson, Hamilton, Hibbard, Hymer, Pursell, and Wickersham; Assistant Professors Gaffney, Henshaw, and Wagner.

Graduate Faculty, Associate Members: Associate Professors Therrien, Witham, and Wood; Assistant Professors Abplanalp, Costantino, Keener, Lennox, Mitchell, Neff, and Raleigh.

The department will direct graduate programs in behavior, cell biology, cytology, cytochemistry, environmental science, ultrastructure, and other aspects of modern biology. The courses of study are planned individually by the student and an adviser. The language and communications requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Admission is restricted to students who have the baccalaureate degree in a biological science and who present a 2.80 junior-senior average. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the requirements for admission can be made for students with degrees in related subjects who will remedy their undergraduate deficiencies concurrently with their graduate studies.

BIOLOGY (BIOL)

402. Vertebrate Neuroanatomy (3)
403. (Ent.) Systematics (3)
404. Practicum in Experimental Neuroanatomy (1-4)
405. General Cytology (3)
*406. Seminar in Neuroanatomy (1-6)
407. Plant Anatomy (3)
410. General Limnology (3)
411. Plant Biology for Teachers (3)
412. Plant Biology for Teachers (3)
414. Advanced Systematic Botany (3)
415. The Literature of Zoology (1)
416. The Methods of Research in Zoology (2)
417. Invertebrate Zoology (3)
418. Mycology (3)
419. General Ecology (3)
420. (Geol. 420) Paleobotany (3)
421. Comparative Anatomy of Vertebrates (4)
422. Advanced Genetics (3)
423. (Geol. 423) Introductory Palynology (3)
424. Botanical Technique (3)
425. Genetics of Fungi (3)
426. Introductory Cytogenetics (3)
427. Evolution (3)
428. The Genetical Theory of Natural Selection (3)
430. (Bphys. 430) Molecular Biology of the Gene (3)
431. Comparative Plant Morphology (2)
432. Laboratory in Comparative Plant Morphology (2)
437. Histology (4)
440. Embryology (4)
441. Plant Physiology (3)
442. Plant Physiology (3)
443. Plant Physiology (3)
444. Biological Problems (1-6)
445. Plant Growth Substances (3)
448. Ornithology (3)
450. Plant Autecology (3)
451. Plant Synecology (3)
452. Ichthyology (3)
461. Animal Parasitology (3)
462. (Pty.Sc. 462, Psy. 462) Animal Behavior—Ethology (3)
463. (Pty.Sc. 463, Psy. 463) Animal Behavior Laboratory (1-2)
470. Comparative Environmental Physiology (4)
472. Vertebrate Physiology (3)
473. Laboratory in Vertebrate Physiology (2)
475. Cellular Physiology (4)
479. General Endocrinology (3)
480. Marine Biology (4)
481. Aquatic Botany (3)
496. Current Topics in Biology (1-6)

500. Plant Physiology Seminar (1 per term) Selected topics from recent literature; staff and student reports on current research. Spring term, even years.

*May be repeated for up to 6 credits.

502. The Physiology of the Fungi (3) Chemical composition, metabolism, toxic and stimulating agencies, spore germination, growth and irritability of the fungi. Fall term, even years.

505. Cytology and Cytogenetics (3) Chromosome mechanism of heredity; relationship between plant and animal evolution and breeding and changes in chromosomes; cytological and cytochemical techniques. Prerequisite: Biol. 405 or 422.

506. Comparative Anatomy of Vascular Plants (3) Structure of the Tracheophyta from a phylogenetic standpoint. Prerequisite: Biol. 407. Spring term, even years.

511. Advanced Plant Physiology (3) Physiology of plants including uptake of water and minerals, translocations, mineral nutrition, energy relations, respiration and catabolism. Prerequisite: Biol. 442. Fall term.

512. Advanced Plant Physiology (3) Continuation of Biol. 511. Physiology of plants including photosynthesis, synthesis of cellular constituents, growth and development. Prerequisite: Biol. 442. Winter term.

513. Biology Seminar (1 per term) Presentation and discussion of selected topics.

516. Ecological Plant Geography (3) Distribution of plant communities; environmental factors which influence their present distribution; geological-historical development of plant communities, their past distribution. Winter term, odd years.

518. Special Problems (1-6) Prosecution of an assigned problem under the guidance of a staff member. Throughout the year as arranged. By appointment.

519. Zoogeography (3) The present distribution of world vertebrates, their evolution, and their patterns of dispersal in the past.

521. Medical and Industrial Mycology (3) Structure, life histories, classification, and techniques of study of the fungi pathogenic to man and of fungi important in industry. Fall term, odd years.

522. Myxomycetes, Phycomycetes, and Ascomycetes (4) Morphology, taxonomy, phylogeny, and life histories; identification and field work. Prerequisite: Biol. 418. Winter term, even years.

523. Basidiomycetes and Fungi Imperfecti (4) Morphology, taxonomy, phylogeny, and life histories. Prerequisite: Biol. 418. Spring term, even years.

524. Seminar in Genetics (1 per term)

526. (Geol. 526) Problems in Palynology (1-6) Systematics; paleoecological palynology; Paleozoic palynology; Mesozoic and Cenozoic palynology; Pleistocene vegetational history.

528. Biometrical Genetics (3) Hereditary structure of populations fusing the principles of genetics, mathematics and statistics, genetic analysis of quantitative traits, artificial selection theory. Prerequisite: Biol. 428 and Stat. 402 or Agro. 545.

531. Bryology (3) Morphology, taxonomy, and ecology of liverworts, hornworts, and mosses; collection, preservation, culturing, and cytologic techniques. Spring term, even years.

533. Problems in Genetics (2-6) Problems to suit needs of individual students; conferences and laboratory work.

535. Morphology of the Tracheophyta Exclusive of Angiosperms (3) Origin,

developmental tendencies, structure, and paleobotanical evidence. Winter term, odd years.

536. Morphology of Angiosperms (3) Floral origin and development, fertilization, embryogeny, seeds and fruit development. Prerequisite: Biol. 400.

537. (Sec.Ed. 537) Workshop in the Biological Sciences (3) Projects designed for teachers of biology in the secondary schools. Summer term only.

538. Principles of Microscopic Histochemistry (2) Theoretical basis for the microscopic identification, localization, and quantitative analysis of chemical substances in tissues of organisms. Prerequisite: Biol. 405 or 437.

539. Analytical Histochemistry Laboratory (2-4) Application of histochemical techniques in the microscopic analysis of tissue lipids, proteins, carbohydrates, nucleic acids and proteins. Prerequisite or concurrent: Biol. 538.

540. Phycology (4) Comparative morphology, taxonomy, and ecology of fresh water and marine algae; culturing, collection, preservation techniques. Prerequisite: Biol. 424.

541. Comparative Physiology (3) Phylogenetic variation in the regulation of the internal environment of animals.

546. Principles of Animal Populations (3) Ecological laws governing population growth and decline; reproductive and mortality rates; predation and composition as limiting factors. Fall term.

571. (Phsio 571) Animal Physiology (2) Physiology of fluid transport mechanisms; examination of the distribution and regulation of body fluids, blood, and hemodynamics. Prerequisite: 3 credits in physiology.

572. (Phsio. 572) Animal Physiology (2) Examination of nutrition, metabolism, and respiration as they relate to subcellular, cellular, and organ organizational levels of the whole animal. Prerequisite: 3 credits in physiology.

573. (Phsio. 573) Animal Physiology (2) Detailed examination of animal reproduction, endocrine secretion and control, neural muscular activity, central nervous system correlates, and special senses. Prerequisite: 3 credits in physiology.

574. (Phsio. 574) Animal Physiology Laboratory (1-6) Selected problems using advanced physiological techniques to study transport mechanisms, circulation, excretion, respiration, metabolism, and neuroendocrines. Prerequisite: Biol. 473.

575. Advanced Cell Physiology (3) Current topics and experiments in cell physiology.

581. Advanced Invertebrate Zoology (3) Morphology, physiology, taxonomy, and life histories of invertebrate animals.

582. (Pty.Sc. 582, Psy. 582) Research in Animal Behavior (2-6 per term) Research in special areas of animal behavior involving field or laboratory work.

583. Experimental Endocrinology (4) Problems in endocrinology designed to demonstrate the role of hormones in the regulation of physiological phenomena.

BIOPHYSICS (BPHYS)

WILLIAM D. TAYLOR, *Head of the Department*
618 Life Sciences Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Deering, Ginoza, Person, and H. Schraer; Associate Professors Morgan, Smyth, Snipes, Strother, and Taylor; Assistant Professors Rake and Todd.

Graduate Faculty, Associate Member: Assistant Professor Scheie.

This program is designed for those interested in applying physical methods to the problems of living systems. Courses are offered in molecular biophysics (an introductory course), nucleic acids, radiation action, cellular physiology, biophysical instrumentation, general biophysics, physics of viruses, and physics of the cell. Advice on the selection of other courses to meet the needs of each student is provided by the faculty. These include courses in physics, chemistry, biochemistry, zoology, botany, and microbiology. The language and communications requirement for the Ph.D. degree may be satisfied by one foreign language and proficiency in English.

A student with a degree in physics, biology, chemistry, or engineering is eligible for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Opportunity to make up possible undergraduate deficiencies is provided in the program.

BIOPHYSICS (BPHYS)

410. SPECIAL TOPICS (1-6)
430. (Biol. 430) MOLECULAR BIOLOGY OF THE GENE (3)
473. INTRODUCTORY BIOPHYSICS (3)
474. MOLECULAR BIOPHYSICS I (3)
475. MOLECULAR BIOPHYSICS II (3)

580. BIOPHYSICAL SCIENCE (3) Enzyme kinetics; thermodynamics of biological systems; molecular theory of reaction rates; structural aspects of biological reactions. Prerequisite: Bphys. 474 or Chem. 451.

581. RADIATION BIOPHYSICS (2) The action of ionizing radiation and of radioactive decay on biological systems: molecular and cellular aspects. Prerequisite: Bphys. 475.

582. BIOPHYSICS OF NUCLEIC ACIDS (3) Biophysical studies on the structure and function of the nucleic acids, particularly those of bacterial and viral origin.

583. SPECIAL TOPICS IN BIOPHYSICS (1-6 per term)

584. SEMINAR IN BIOPHYSICS (1-3 per term)

585. BIOLOGICAL ULTRASTRUCTURE (4) The application of electron microscopy to the study of cell biology. Prerequisite: any of the following—Bphys. 473; Biol. 405, 437; Micrb. 401.

586. BIOLOGICAL MACROMOLECULES (3) Biopolymer characteristics; polymer statistics; size and shape determination; methods of separation; polyelectrolytes; optical and mechanical properties; denaturation; degradation; biosynthesis. Prerequisite: Bphys. 475 or Chem. 451.

587. Ultracentrifugation (2) A laboratory course in ultracentrifugation techniques including applications to biophysical problems. Prerequisite: Bphys. 474.

588. Physiology of Nerves, Muscles, and Sense Organs (2-6) Current literature on the function of nerves, muscles, and receptors. These subjects are considered individually in successive years. Prerequisite: a 400-level course in physiology, biophysics, or physiological psychology.

589. Mammalian Cell Culture (3) Recent research in quantitative cell biology as studied with tissues and cells of higher organisms cultured *in vitro*. Prerequisite: Bioch. 401.

590. Photobiology (2) Effects of visible and ultraviolet light on biological systems: energy absorption, transfer, utilization; photochemistry; metabolic and genetic responses; repair systems.

591. Microspectrophotometry (2) Principles of absorption spectroscopy; microspectrophotometer design; determination of cellular constituents using stained and unstained preparations; laboratory exercises. Prerequisite: graduate student standing.

595. Electron Spin Resonance Spectroscopy (3) Experimental and theoretical aspects of electron spin resonance spectroscopy to provide ability for its application to biophysical problems. Prerequisite: basic knowledge of quantum mechanics and electromagnetic waves.

BOTANY (BOT)

Joseph G. O'Mara, *Head of the Department of Biology*
208 Life Sciences I Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Fergus, Grove, Grun, Hillson, Kneebone, Kovar, O'Mara, Schein, Spackman, Traverse, and Wright; Associate Professors Hamilton and Pursell; Assistant Professor Wagner.

Graduate Faculty, Associate Members: Associate Professors Thieren and Witham; Assistant Professors Costantino, Keener, and Lennox.

Botanical programs are offered in plant anatomy, cytology, ecology, genetics, morphology, mycology, physiology, and taxonomy. A student having a degree in science or in one of the biological sciences is eligible for admission. Entering graduate students should have had basic courses in chemistry, mathematics, and physics. The language and communications requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests.

See also Genetics and Physiology.

Note: *For courses in Botany and related subjects see Biology.*

BUSINESS ADMINISTRATION (B A)

MAX D. RICHARDS
In Charge of Graduate Programs in Business Administration
102A Boucke Building

Degrees Conferred: Ph.D., M.S., M.B.A.

Graduate Faculty, Senior Members: Professors Beik, Bennett, Bradley, Carroll, Clewett, Cook, Coyle, Cramer, Ferrara, Greenlaw, Hammond, Hottenstein, Kelley, McKinley, Pashek, Philippatos, Philips, Richards, Rigby, Schrader, Shilling, and Waters; Associate Professors Babione, Copeland, Heitmann, Koot, Malcom, Mathews, Slocum, Spier, and Spychalski.

Graduate Faculty, Associate Members: Professors Nelson, Phalan, and Williams; Associate Professors Curley, Hayya, Koehler, Melander, Miller, Millman, and Strawser; Assistant Professors Bear, Bither, Carpenter, Dolich, and Susman.

The M.B.A. is a professional program for education in business administration to prepare individuals for administrative positions in business, institutional, and governmental management. Both applicants whose undergraduate preparation has been in business and those in fields other than business are encouraged to apply.

Preparatory courses in accounting, business law or the legal environment, business statistics, calculus, financial management, finite mathematics, macroeconomics, microeconomics, management, and marketing are required. The M.B.A. program itself requires 36 credits of graduate courses and a professional paper.

The M.S. and Ph.D. programs with a major in business administration are designed for those interested primarily in research and teaching. The language and communications requirement for the Ph.D. degree may be satisfied by a reading knowledge of two foreign languages or a reading, listening, and speaking knowledge of one language. The candidate may substitute quantitative analysis and/or behavioral science for the required reading knowledge in one or two languages.

For admission to the M.S. program, approximately 30 acceptable undergraduate credits in business administration, economics, and mathematics are required. An applicant may be admitted with deficiencies to be made up without degree credit.

Applicants are evaluated for admission on the basis of academic potential and other factors giving evidence of a high probability of completing the program. Data useful for evaluating academic potential include a 2.50 junior-senior average, ATGSB test scores, and academic recommendations. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Applicants to any of the graduate programs in business administration are required to take the Admission Test for Graduate Study in Business (ATGSB) given by the Educational Testing Service and used by leading graduate business schools throughout the country to supplement other criteria for admission. Candidates are strongly urged to take the test at the earliest possible date. It is given at University Park and at numerous locations in most states and foreign countries in November, February, June, and August. For dates and locations, see the *Bulletin of Information,* Admission Test for Graduate Study in Business, Educational Testing Service, Princeton, New Jersey. Applicants should read the bulletin carefully. All arrangements for taking the test are made directly with the Educational Testing Service.

This graduate program is accredited by the American Association of Collegiate Schools of Business.

ACCOUNTING (ACCTG)

401. Advanced Accounting (3)
403. Auditing (3)
404. Managerial Accounting (3)
406. Advanced Federal Tax Accounting (3)
409. Machine and Electronic Accounting Methods (3)

*398G. Accelerated Elementary Accounting (3) The theory and technique of financial and managerial accounting: preparation, analysis, and interpretation of financial statements. Open to gradute students only.

500. Accounting Seminar (3-6)

503. Seminar in Auditing (3) The attest function of independent public accountants, verification of financial statements; problems of evidence, independence, ethics, professional responsibilities. Prerequisite: Acctg. 403.

504. Seminar in Managerial Accounting (3-6) Accounting and the managerial processes of planning, control, and decision making.

507. Seminar in Financial Accounting (3) Theoretical basis of financial accounting.

508. Contemporary Issues in Accounting (3) Selected problems of current interest to the accounting profession.

511. Interpretation of Account Data (3)

515. Development of Accounting Thought (3) Development of accounting thought from ancient civilizations to the present.

520. Problems in Accounting (3-6) Planned individual projects involving library, laboratory, or field work.

BUSINESS ADMINISTRATION (B A)

503. Seminar in Public Utilities (3)

538. Information Systems for Planning and Control (3) Analysis of information requirements for planning, decision making and performance measurement in organizations.

540. Business Administration Theory and Practice (3) An integrating course primarily for M.S. students using cases requiring analysis involving interrelated aspects of business administration and control.

541. Readings in Business Administration (6) Critical study and discussion of important topics in business administration.

550. Behavioral Science in Business (3) Application of behavioral science concepts and analytical methods to problems in business organizations. Analysis of administrative behavior and decision making.

552. Business Research Methods (3) Research methods applicable to business problems with emphasis on means of obtaining data and the logic underlying research design.

* No graduate credit is given for this course.

555. Business and Society (3) Evolution of the business organization and the changing framework of its operations, responsibilities, and social control.

574. Business Research (1-3) A project paper, comparable in quality and scope of work to a graduate thesis, on problems of a company. Prerequisite: 15 credits of 400 and 500 courses in business administration.

577. Administrative Integration (3) An analysis of coordination of the functional areas of business in relation to overall company objectives. Prerequisite: 15 credits of 400 and 500 courses in business administration.

BUSINESS LAW (B LAW)

*398G. Accelerated Business Law (3) Social control through law: courts; policies underlying individual rights; negotiable and nonnegotiable contractual rights in society. Open to graduate students only.

BUSINESS LOGISTICS (B LOG)

412. Transport Planning Analysis (3)
420. Urban Transportation (3)
430. Transport Problems (3)
440. Logistics Systems Analysis (3)

504. Problems in Business Logistics (3-6) Planned individual projects involving library, laboratory, or field work.

538. Logistics Systems Management (3) Control of the movement of goods; coordination of supply and demand in creation and maximization of time and place utility.

540. Transport Policy (3) Role of transport in the economy. Transport systems elements, development, cost and pricing characteristics. Public control and public policies.

541. Socioeconomic Analysis in Transportation (3) Role of transport in social and economic activity. Planning and coordination of transport systems. Designed for the Traffic Engineering program.

565. Seminar in Business Logistics (3-6)

FINANCE (FIN)

406. Security Analysis and Portfolio Management (3)
408. Financial Markets (3)

*398G. Accelerated Financial Management (3) Financial planning and forecasting; management of working capital, capital budgeting, and dividend policy; capital structure and valuation. Open to graduate students only.

504. Problems in Finance (3-6) Planned individual projects involving library, laboratory, or field work.

506. Portfolio Theory and Policy (3) Rigorous examination and analysis of asset-holder behavior under conditions of risk and uncertainty.

* No graduate credit is given for this course.

508. Analysis of Financial Markets (3) Analysis of factors affecting price determination in financial markets.

510. Contemporary Issues in Financial Institutions (3) Critical investigation of problems of current interest in the market structure and internal operations of financial institutions.

531. Financial Management (3) An intensive examination of techniques available to aid the financial manager in decision making.

532. Normative Models in Business Finance (3) Application of advanced analytical techniques and models to financial decision making under uncertainty.

541. Financial Theory (3) A theoretical analysis of the elements of finance.

561. Seminar in Finance (3-6) Comparative analysis of research in the theories of finance; relationships to business management practices.

INSURANCE (INS)

400. Estate Planning (3)

500. Insurance Theory and Practice (3) Insurance as an institution, a technique, a legal contract; its environment as a regulated industry.

504. Problems in Insurance (3) Planned individual projects involving library, laboratory, or field work.

510. Risk Management (3) Analysis of managerial problems and responsibility for risk analysis, removal or reduction, and allocation of corporate resources to provide indemnity.

520. Seminar in Insurance (3-6) Selected topics on advanced aspects of risk management with emphasis on the insurance technique for treating hazards.

INTERNATIONAL BUSINESS (I B)

501. The International Environment (3) Conceptual approach analyzing and predicting influences of social, political, and economic norms and values upon diverse societies' managerial decision making.

502. International Business Macro Theory and Policy I (3) International economic trade and monetary tools are applied to current national policy issues to determine effects on international business operations. Prerequisite: Econ. 333.

503. International Business Micro Theory and Policy I (3) Analysis of the internal operations of multinational firms; design of optimal strategies of operation under varying environmental conditions.

504. Seminar in International Business (3-6) Seminar techniques applied to selected topics; market structures; capital budgeting, investment; comparisons of foreign norms and values; multinational organization characteristics.

MANAGEMENT (MGMT)

410. Operations Planning and Control (3)
420. Management of Personnel Systems (3)
422. Advanced Organization Theory (3)
430. Administrative Management (3)

432. Simulation of Management Systems (3)
435. Cases in Public Relations (3)

*398G. Accelerated Business Management (3) The concepts of management and its decision processes including special attention to operations management.

510. Operations Management (3) Integration and application of decision making to operational and policy problems within the business firm.

515. Design of Operation Output Systems (3) Examination of research-based findings in operations management with a focus on the design and reliability of production systems.

516. Operations Planning and Control (3) Examination of research-based findings in operations management. The focus is on the operation and control of production systems.

517. Conceptual Bases of Sociotechnical Systems (3) Integrates behavioral science and operations management in sociotechnical framework. Design of sociotechnical systems.

520. Organization Theory (3) Theoretical and operating structures in formal business organizations; relation of formal organization to informal groups and to individuals.

521. Seminar in Organizational Behavior (3) Examination of research-based findings on organizational behavior. Methodological techniques for studying human behavior in formal organizations.

523. Organizational Change: Theory and Practice (3) Analysis of research, theory and practice in dynamics of organizational change. Research literature reviewed for evaluation of concepts and methods.

531. Management Information Systems (3) Information system theories and methods applied to administrative structures and management decisions in organizations.

540. Personnel Management (3) Theoretical constructs underlying personnel administration; analysis of professional personnel functions in business firms.

590. Seminar in Management (3-6) Comparative analysis of research in the theories of the administrative sciences; relationships to business management practices.

591. Special Topics in Management (3-6) In-depth explorations of special topics of management theory.

MARKETING (MKTG)

424. Marketing Research (3)
435. Marketing and Public Policy (3)

*398G. Accelerated Marketing Management (3) Analyses of customer and market behavior, marketing systems, and competitive strategies; programming product, pricing, distribution, and promotion. Open to graduate students only.

500. Marketing Management (3) Analysis of management's marketing problems including market analyses, pricing, channel of distribution, promotion, competition, product strategies, and marketing research.

* No graduate credit is given for this course.

504. Problems in Marketing (3-6) Planned individual projects involving library, laboratory, or field work.

510. Planning Market Strategy and Programs (3) Development of marketing strategy for the firm and design of integrated product-service, promotion, and distribution programs utilizing systems analysis.

520. Quantitative Analysis for Marketing Decisions (3) Sales forecasting, new product proposals, media selection, and market testing analyzed using statistical and decision theory and other mathematical techniques.

530. Consumer and Market Behavior (3) Buying behavior: concepts from the behavioral sciences, including utility, culture, life cycle, personality, attitudes, and learning.

540. Marketing and Society (3) Marketing problems of society; domestic and regional marketing systems; governmental policies toward marketing; social performance of marketing.

544. Marketing Theory (3) The development of marketing concepts, behavioral and other marketing theories; public policy and the role of marketing in societies.

560. Seminar in Marketing (3-6) Research in modern marketing trends.

QUANTITATIVE BUSINESS ANALYSIS (Q B A)

403. Intermediate Business Statistics (3)
404. Sampling in Business Operations and Research (3)
451. Analytical Methods in Business (3)
452. Analytical Methods in Business (3)
461. Probabilistic Models in Business (3)
490. Special Topics (3-6)

*398G. Accelerated Business Statistics (3) Basic characteristics of univariate and bivariate distributions, probability theory, introduction to estimation, tests of hypotheses, and time series analysis. Open to graduate students only.

500. Seminar in Business Statistics (3-6)

501. Advanced Business Statistics (3)

510. Statistics in Business Research (3) Statistical principles and procedures essential to the interpretation and performance of research in business administration. Prerequisite: common requirements of M.B.A. program.

521. Quantitative Analysis for Business Decisions (3) Construction and use of quantitative models in business decision making. Prerequisite: common requirements of M.B.A. program.

527. Statistical Decision Theory (3) A systematic survey and analysis of the concepts and methods of Bayesian statistical decision theory.

570. Management Science: Implementation and Control (3) Development and application of management science models. Model formulation and specification, sensitivity analysis, problems encountered in implementation and control.

REAL ESTATE (R EST)

400. Urban Land Utilization (3)

* No graduate credit is given for this course.

BUSINESS EDUCATION (BUSED)

Joseph T. Impellitteri
In Charge of Graduate Programs in Business Education
248 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professor House, Associate Professor Impellitteri.

This program provides advanced preparation for teachers of business subjects for secondary schools and colleges. The subject-matter areas encompass secretarial, accounting, retailing, clerical, and general business sequences. The program may be adapted for the preparation of supervisors of business education.

All students specializing in business education are encouraged to acquire a general education in the social sciences, the behavioral sciences, and the humanities.

The above applies to students who are already in the program. New admissions to this program have been suspended. Students interested in this field are advised to consult with Dean Robert Lathrop, 240 Chambers Building, College of Education, concerning alternative programs.

BUSINESS EDUCATION (BUSED)

456. Principles and Problems in Business Education (1-3)
459. Improvement of Instruction in Business Skill Subjects (1-3)
460. Curriculums in Business Education (3)
461. Improvement of Instruction in Basic Business Subjects (3)
462. Teaching of Shorthand and Typewriting (3)
463. Teaching of Bookkeeping (3)

511. Internship in Business Education Supervision (3-6) Internship to take place in schools or educational situations where student is not regularly employed, under supervision of graduate faculty.

575. Administration and Supervision in Business Education (3) Work of administrators, supervisors, and others responsible for improvement of instruction in business education; use of vocational testing; job analysis. Prerequisite: 6 credits in secondary education.

576. Introduction to Research in Business Education (3) Methods of research in business education; opportunity to compile annotated bibliographies on current problems; analysis and evaluation of significant research.

577. Evaluation of Research and Empirical Literature in Business Education (3) Application of evaluation methods to current literature in business education; special attention to research studies. Prerequisite: Bus.Ed. 576.

578. Seminar in Business Education (1-6) Intended for graduate students preparing theses or final documents, or for those working on special studies in business education. Prerequisite: Bus.Ed. 577.

CERAMIC SCIENCE (CERSC)

Guy E. Rindone
In Charge of Graduate Programs in Ceramic Science
201 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Hummel, Kline, Newnham, Rindone, and Williamson; Associate Professors McKinstry and Stubican.

Graduate Faculty, Associate Member: Assistant Professor Bradt.

This program is one of the options in which a graduate student in the Department of Materials Science can receive an advanced degree. In view of the wide field covered by ceramic science, the graduate courses may be selected with a bias toward physical ceramics, chemical ceramics, or glass science.

The language and communications requirement may be satisfied by (1) examinations in two languages—French examination administered by the ceramic science faculty and a second language examination by the appropriate language department or (2) examination in one foreign language *and* either 6 credits of computer science or 6 credits of statistics.

Special facilities exist for research in the areas of electroceramics, rheology, phase equilibria, solid state synthesis, mechanical properties, ferrite and ferroelectric studies, glass science, and high temperature reaction kinetics. Suitable preparation for graduate study in this program may be found in one of the materials sciences such as ceramics, or metallurgy; in engineering fields such as chemical or mechanical engineering; in the basic physical sciences; or in the earth sciences.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

CERAMIC SCIENCE (CERSC)

400. (Min. 400) Nonmetallic Crystal Chemistry (2)
402. Principles of Ceramic Engineering (3) *Mr. Williamson*
404. Ceramic Seminar (1) *Mr. Hummel*
405. Ceramic Research and Design (1)
406. Rheology and Fluid Properties of Ceramic Systems (2) *Mr. Williamson*
407. Ceramic Materials Laboratory (2) *Mr. Williamson*
408. Heat Treatment of Ceramic Materials (1) *Mr. McKinstry*
409. Heat Treatment Laboratory (2) *Mr. McKinstry*
410. Phase Relations in Ceramic Systems (3) *Mr. Hummel*
411. Principles of Ceramic Processes (2) *Mr. Stubican*
414. Mechanical Properties of Ceramics (3) *Mr. Bradt*
415. Principles of Glass Technology (3-4) *Mr. Rindone*
420. Refractories (2-3) *Mr. Stubican*
425. Ceramic Research and Design (2)
430. Electroceramics (2-3) *Messrs. Cross and Biggers*

500. Seminar in Ceramic Science (1-2 per term) Current developments in ceramic science and related fields. Required of all graduate students in ceramic science. *Mr. Hummel and Staff*

501. Surface Behavior of Ceramic Materials (2-4) Surface chemistry of ceramics. Rheology of ceramic powders, suspensions and pastes. *Mr. Williamson*

503. Use of Phase Equilibria Data in Ceramic Science (2-5) Phase equilibria in unary, binary, ternary, and other systems; applications in product development and in understanding behavior of ceramic materials. *Mr. Hummel*

504. Solid State Reactions in Ceramic Systems (2) Thermodynamic, kinetic, and structural study of reactions and of equilibrium in ceramic systems. Prerequisites: Chem. 451, 452. *Mr. Stubican*

505. Phase Transition in Solids (2) Phase transitions will be studied in detail with respect to the crystal structure, free energy, and physical properties. *Mr. McKinstry*

506. Mechanical Properties of Ceramics (3) Theoretical consideration of internal stresses, dislocations and dislocation processes, and macro- and microstructural variables on the mechanical properties of ceramics. Prerequisite: Cer.Sc. 414. *Mr. Bradt*

507. Thermal Properties of Ceramic Materials (2-3) Heat capacity, heat of fusion, thermal conductivity, and thermal expansion in relation to macroscopic measurements and basic atomic concepts applied to ceramic materials. *Mr. Stubican*

508. Dielectric and Magnetic Properties of Ceramic Materials (2-3) Preparation and properties of ceramic semiconductors, dielectrics, and magnetic materials. *Mr. Newnham*

509. Composite Materials (3) Manufacturing processes, atomic and molecular background, and topological relationships of macro- and microstructure to the physical properties of composites. *Mr. Bradt*

510. Seminar in Glass Technology (1-2 per term) Current developments in glass technology and related fields. *Mr. Rindone*

511. The Constitution of Glass (2-3 per term) Historical and current concepts of the atomic structure of glass; relationship of structure to chemical and physical properties. *Mr. Rindone*

512. Selected Properties of the Vitreous State (2-3 per term) Measurement and interpretation of such properties as: radiation effects; viscoelasticity; electrical, mechanical, optical, and thermal properties. *Mr. Rindone*

515. Special Problems in Ceramic Science (1-6 per term) Advanced individual study on a problem in ceramics.

516. Selected Topics in Ceramic Science (1-3 per term) Intensive group study of special topics.

530. (Min. 530) Structure, Properties, and Occurrence of Clay Minerals (2-5) Structure analysis and identification of clay minerals; mineral transformation and behavior; occurrence, genesis, and petrography of fine-grained sediments. *Messrs. Brindley and Hsu*

Note: *Courses in the use of X-ray diffraction, electron microscopy, and the electron microprobe in ceramic science studies are listed under Materials Science.*

CHEMICAL ENGINEERING (CH E)

LEE C. EAGLETON, *Head of the Department*
160 Chemical Engineering Building West

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Braun, Eagleton, Jones, Klaus, and McCormick; Associate Professors Daubert, Engel, and Kabel.

Graduate Faculty, Associate Members: Assistant Professors Barton and Danner.

Course offerings or research facilities are available in the following areas: phase equilibria, thermodynamics, kinetics, mass transfer, transport phenomena, unit operations, unit processes, bioengineering, applied chemistry and petrochemistry, petroleum technology, rheology, and lubrication.

The language and communications requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages or by comprehensive knowledge of one.

To be admitted, a student should be a graduate of an accredited major in chemical engineering or the equivalent. Graduates of other accredited engineering or physical science majors may be admitted but will be required to make up certain undergraduate deficiencies without graduate credit. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

CHEMICAL ENGINEERING (CH E)

404. CHEMICAL ENGINEERING ECONOMICS (3)
405. THERMODYNAMICS FOR CHEMICAL ENGINEERS (3)
406. CHEMICAL ENGINEERING PROBLEMS (3)
410. CHEMICAL ENGINEERING PRINCIPLES (3)
411. CHEMICAL ENGINEERING PRINCIPLES (3)
412. CHEMICAL ENGINEERING PRINCIPLES (3)
415. ANALYSIS AND MATHEMATICAL SIMULATION IN CHEMICAL ENGINEERING (3)
420. CRYOGENIC ENGINEERING (3)
422. PETROLEUM PROCESSES AND PRODUCTS (2)
426. INTRODUCTION TO TRANSPORT PHENOMENA (3)
430. NUCLEAR CHEMICAL ENGINEERING (3)
435. CHEMICAL REACTION KINETICS (2)
440. CHEMICAL ENGINEERING MATERIALS (3)
445. CHEMICAL ENGINEERING RESEARCH (1-5)
450. PROCESS DYNAMICS (3)
460. CHEMICAL ENGINEERING (4)

500. SEMINAR IN CHEMICAL ENGINEERING (1) Required of all graduate students.

505. SPECIAL TOPICS IN CHEMICAL ENGINEERING (2-12) Intensive study in the various specialized fields of chemical engineering.

508. PRINCIPLES OF INDUSTRIAL ORGANIC CHEMISTRY (3) Principles and practices of modern conversion processes in the manufacture of organic chemicals. Prerequisites: Chem. 31, 452; Ch.E. 30.

509. HEAT TRANSFER APPLICATIONS (3) Advanced treatment of steady-state and

transient conduction, convection, and radiation, with emphasis on numerical methods and design techniques. Prerequisite: an undergraduate course in heat transfer.

515. Distillation (3) Commercial distillation, equilibrium diagrams, vapor composition, stills and rectifying and stripping columns.

516. Methods of Process Design (3) Survey of mathematical techniques of chemical process design with emphasis on economic choice and optimal decision making.

520. Extraction Processes (3) Equilibrium extraction data and phase contacting and settling related to equipment design.

521. Transport Phenomena (3) Momentum, heat, and mass transfer in boundary layers and turbulent fluids; ideal potential flow; unsteady state and coupled transport.

522. Special Topics in Transport Phenomena (3) Intensive group study and discussion of current problems and techniques in transport processes. Prerequisite: Ch.E. 521.

524. Chemical Engineering, Application of Thermodynamics (3) Elements of thermochemistry and thermodynamics of greatest importance in chemical engineering.

535. Chemical Reaction Engineering (3) Optimal design of batch and continuous chemical reactors and reactor batteries; effect of mixing on reactor operation. Prerequisite: Ch.E. 435.

CHEMISTRY (CHEM)

Joseph A. Dixon, *Head of the Department*
212 Whitmore Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Allcock, Benkovic, Bernheim, Deno, Dixon, Fritz, Haas, Hisatsune, Jackman, Jordan, Lampe, Miller, Richey, Rosenblatt, Shamma, Skell, Steele, Wartik, and Zook; Associate Professors Ascah, Gold, Hamilton, Hayes, Heicklen, Horrocks, Lowe, Olofson, and Schempf.

Graduate Faculty, Associate Members: Assistant Professors Crawford, Jurs, Long, Lotz, Riehl, Seeley, and Stanko.

Students may specialize in analytical, inorganic, organic, or physical chemistry. The general facilities are excellent, and the computer, cryogenic, radiochemical, and spectroscopy laboratories provide unusual research opportunities. Distinguished visiting scholars conduct informal discussion each Thursday at a departmental colloquium. The department requires a knowledge of German as a condition for awarding either the M.S. or Ph.D. degree. Candidates who have taken and passed two undergraduate courses in German will be certified as having completed the language and communications requirement. For the M.S. degree the student has the option of writing a thesis or a paper.

For admission, at least integral calculus plus one year's work in general physics, organic chemistry, physical chemistry, and either analytical or inorganic chemistry is normally required. Students who have appropriate course backgrounds and who present a 2.50 average in all undergraduate courses in chemistry, physics, and mathe-

matics will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Prior to scheduling their first term programs, new students will take examinations in three of the four areas of analytical, inorganic, organic, and physical chemistry. The information obtained from these tests will assist both the student and his adviser in making up a program best suited to the student's needs. These examinations are normally given just prior to the regular registration period.

CHEMISTRY (CHEM)

400. Chemical Literature (1)
401. Seminar (1)
405. Nuclear and Radiochemistry (3)
408. (Cmp.Sc. 408) Computer Applications in Chemistry (3)
410. Inorganic Chemistry (2)
411. Advanced Inorganic Chemistry (2)
412. Experimental Inorganic Chemistry (2)
423. Advanced Analytical Chemistry (3)
424. Advanced Analytical Laboratory (2)
426. Chemical Instrumentation (3-5)
431. Advanced Organic Chemistry Laboratory (3)
435. Advanced Organic Chemistry Laboratory (3)
439. Advanced Organic Chemistry (3)
448. Colloid Chemistry (3)
*451-452. Physical Chemistry (3 each)
453. Advanced Physical Chemistry (3)
454. Advanced Physical Chemistry (3)
455. Physical Chemistry of High Polymers (3)
*457. Experimental Physical Chemistry (2)
*458. Experimental Physical Chemistry (1)
489. Introduction to Chemical Research (1-10)
493. Selected Topics in Chemistry for Teachers (3-9)

500. Seminar in Inorganic Chemistry (1 per term)

501. Seminar in Physical Chemistry (1 per term)

502. Seminar in Organic Chemistry (1 per term)

503. Seminar in Analytical Chemistry (1 per term)

516-517. Inorganic Chemistry (3 each) Systematic treatment of inorganic chemistry in terms of modern concepts.

518. Special Topics in Inorganic Chemistry (3 per term) Modern developments in specialized fields.

525. Analytical Processes (3) Theoretical foundations and contemporary developments.

526. Modern Instrumental Analysis (3)

527. Special Topics in Analytical Chemistry (2-12)

531. Special Topics in Organic Chemistry (3-12)

*Graduate credit not allowed for students majoring in chemistry or chemical engineering

534. Chemical Applications of Quantum Theory (3) A development of Molecular Orbital Theory up to the level of present-day usage in organic and inorganic chemistry.

535-536. Organic Chemistry (3 each) Adapted to the needs of those doing research work in organic chemistry.

538. Organic Chemistry (3) Survey of organic chemistry arranged primarily for graduate students majoring in fields other than organic chemistry.

544. Chemical Thermodynamics (3) Development of thermodynamic theory with special reference to common physical changes and chemical reactions. Prerequisite: Chem. 452.

545. Statistical Thermodynamics (3) The calculation of thermodynamic properties from molecular and spectroscopic data. Prerequisites: Chem. 544, 565.

560. Topics in Physical Chemistry (2-6)

563. Chemical Kinetics (3) Theory and measurement of the rates of chemical reactions, molecular dynamics, and mechanisms of chemical reactions. Prerequisites: Chem. 544, 565.

565. Atomic and Molecular Structure (3) Introduction to modern theoretical chemistry, spectroscopy, and structure of atoms and molecules.

566. Quantum Chemistry (3) Theoretical calculations of electronic properties of atoms and molecules. Prerequisite: Chem. 565. Prerequisite or concurrent: Math. 555.

567. Quantum Chemistry (3) A continuation of Chem. 566, including problems and theories of electron correlation. Prerequisite: Chem. 566.

571. Polymer Chemistry (3) The synthesis, reactions, and structure determination of high polymers.

589. Studies in Chemistry (1-9) Theoretical research, experimental research, or a critical survey of the literature in an area of chemistry.

CHILD DEVELOPMENT AND FAMILY RELATIONSHIPS (CD FR)

(See Human Development and Family Studies)

CIVIL ENGINEERING (C E)

Benjamin A. Whisler, *Head of the Department*
212 Sackett Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty, Senior Members: Professors Barnoff, Gotolski, Hurd, Larson, Nesbitt, and Whisler; Associate Professors Cady, McDonnell, Reich, and Taylor.

Graduate Faculty, Associate Members: Professor Weeden; Associate Professors Davinroy and Mozingo; Assistant Professors Aron, Atakol, McClure, Unz, and West.

Students may specialize in structures, hydraulics, hydrology, transportation engineering, traffic engineering, materials, soils, and sanitary engineering, or combinations of these. Relevant courses are offered both by the Department of Civil Engineering and by other departments of the University.

The language and communications requirement for the Ph.D. degree may be satisfied by a reading, writing, and speaking ability in English and a reading knowledge of an acceptable foreign language.

Candidates must be graduates in civil (or sanitary) engineering from an accredited college of engineering. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

See also Sanitary Engineering.

CIVIL ENGINEERING (C E)

400. Seminar (1-3)
401. Civil Engineering Projects (2-12)
421. Highway Engineering (3)
422. Transportation Engineering (3)
423. Traffic Characteristics and Measurements (3)
424. Civil Engineering Materials (3)
431. Civil Engineering Construction (3)
446. Advanced Soil Mechanics (3)
447. Structural Analysis by Matrix Methods (3)
448. Advanced Structural Design (3)
451. Advanced Hydrology (3)
452. Water Resources and Computations (4)
462. Open Channel Hydraulics (3)
465. River and Waterways Engineering (3)
471. Environmental Sanitation (3)
472. Water Pollution Control (3)

500. Seminar in Civil Engineering (1-6) Reports on researches and special topics. Course may be continued in subsequent terms.

501. Civil Engineering Projects (3-10) Investigation or design projects in structures, transportation, hydraulics, or civil engineering materials.

511. Engineering Soil Characteristics (3) Physical and chemical factors in soil which influence their engineering properties of strength, deformation, permeability, and soil stabilization.

512. Applied Soil Mechanics (2-5) Soil classification by type of clay minerals and profile development; aerial photographic interpretation of soils and applications to site selection for dams, highways, and airports.

513. Soil Exploration and Analysis (3) Laboratory evaluation of parameters used in modern soil mechanics. Involved techniques of soil testing, test limitations, sampling influences, technical reports.

519. Traffic Administration and Finance (2) Organization and administration of traffic engineering at various levels of government; leaders in the highway transportation field are guest lecturers.

520. Pavement Design (3) Fundamental principles; properties of pavement components; design tests; design of flexible pavements; design of rigid pavements; pavement evaluation and strengthening.

521. Techniques of Transportation Analysis (2-4) Transportation functions, travel patterns, basic analytical methods in the planning content.

522. Highway Operations (2) Theory and application of traffic controls, including functional operations of traffic signals, systems, and networks; the design of highway lighting.

523. Urban Transportation Planning (2-4) The problem in historical perspective, current content, costing procedures, public policy, the planning process.

524. Advanced Problems in Civil Engineering Materials (2-6) Study, in the literature and by laboratory investigation, of selected topics on field-controlled civil engineering materials. Prerequisite: C.E. 424.

525. Airport Planning and Design (3) Aircraft characteristics; aeronautical demand; site selection; airport configuration; capacity analysis; design of landing and terminal areas.

526. Design of Transportation Facilities (3) Basic principles and engineering design of truck terminals, railroad yards and terminals, bus terminals, and parking facilities.

527. Theory of Traffic Flow (3) Phenomenon of vehicular traffic flow; flow density relationships; spacing; gap counting; delays; problems involving interrupted flow; multiflow routes.

528. Queuing Models in Transportation (3) Arrival patterns; the service mechanism; queue discipline; delays; multiple queues; problems involving various combinations of queues and service facilities.

529. Highway Geometric Design (3) Principles of road and parking terminal design with emphasis on operations; highway planning related to alternate solutions of design problems. Prerequisites: C.E. 423, 522.

533. Ultimate and Plastic Design Methods (3) Plastic design of steel structures. Limit design of concrete structures. Ultimate theories applied to plate and slab problems.

537. Matrix Method of Structural Analysis (3) Analysis of structures using advanced matrix techniques, transformation of matrices, energy concepts, iterative solutions, applications to linear and nonlinear structures. Prerequisite: C.E. 447.

539. Approximate Methods of Structural Analysis (3) Newmark's method, finite difference method, and finite element method applied to problems in structural and soil engineering.

540. Advanced Structural Analysis I (3) Analysis of continuous beams, frames on elastic supports, grids, and arches under various loading conditions. Influence lines and deformations.

541. Advanced Structural Analysis II (3) Redundant, continuous, hybrid trusses, influence lines; secondary stresses; framed arches; suspension systems, selection of bridge type; space framing.

544. Advanced Design of Concrete Structures (3) Concrete working stress, ultimate strength, limit design; test behavior of beams, slabs, columns; simple and continuous prestressed concrete members.

545. Advanced Structural Design (2-4) Steel, aluminum members; flexible connections; composite, hybrid, prestressed beams; tension-field beams; buckling; plastic analysis, design; test data; timber design. Prerequisite: C.E. 41.

546. Thin Concrete Structures (3) Design of thin concrete structures including slabs, folded plates, and shells.

548. Structural Design for Dynamic Loads (3) Dynamic behavior of structural systems of one and more degrees of freedom; earthquake, blast-resistant analysis, and design of structures.

549. Long Span Structures (3) Analysis and design of suspension bridges, cable roofs, and arch-type structures.

550. Engineering Construction Management (2-4) Management fundamentals for construction contracting; organization, project planning, scheduling and control, bonding and insurance, labor legislation and regulation, cost and control. Prerequisite: C.E. 431.

551. Hydrologic Investigations (2-8) Application of hydrologic principles and techniques to a specific project.

552. Hydrologic Processes and Cybernetics (3) Application of cybernetic concepts in electronic computer simulation of the hydrologic process-components: infiltration, precipitation, evapotranspiration, and overland flow. Prerequisite: C.E. 51 or 452.

553. Planning Multipurpose Hydrologic Systems (3) Study of multipurpose hydrologic schemes within a social, economical, and political framework. Prerequisite: C.E. 451 or 452.

554. Urban Hydrology (3) Several hydrograph methods. Design storm and IUH application; airport drainage; flood planes; impact of urbanization upon groundwater and sediment. Prerequisite: C.E. 451 or 452.

560. Dimensional Analysis and Theory of Models (3) Principles of dimensional analysis and similitude with engineering applications.

564. Hydraulic Engineering Design (2-8) Design and analysis of selected units of a typical hydraulic engineering project.

565. Transportation of Solids by Fludis (2-5) Fundamentals of the flow of solids in open and closed conduits; e.g., suspended load and bed load in rivers, slurries and pulp stocks in pipes.

571. Water Treatment Theory (3) Theory of modern methods of conditioning water for municipal and industrial use. Prerequisite: C.E. 472.

572. Waste Treatment Theory (3) Theory of modern methods of waste treatment. Prerequisite: C.E. 472.

573. Problems in Environmental Pollution Control (3-9) Investigations, analyses, and reports on current topics in environmental pollution control.

574. Laboratory Analyses in Water Quality Control (3) Experiments illustrating current chemical and biochemical methods of water and waste treatment and analytical methods used in research and control.

575. Advanced Industrial Waste Treatment (3) Techniques of industrial waste treatment; attendant stream pollution and stream self-purification factors. Prerequisite: C.E. 472 or 572.

576. Water Treatment Plant Design (1-6) Design of works for treatment of water for municipal and industrial use. Prerequisite: C.E. 71.

577. Waste Treatment Plant Design (1-6) Design of works for the treatment of municipal or industrial wastes. Prerequisite: C.E. 71.

579. (Micrb. 529) Aquatic Microbiology (3) Ecology and physiology of microorganisms of inland waters, estuaries, and oceans; microbiology of wastewater treatment. Prerequisite: introductory microbiology.

580. Stream and Estuarine Analysis (3) Quantitative assessment of advection, reaction, and dispersion processes in polluted waters; reaeration theory; eutrophic systems; analog simulation. Prerequisite: C.E. 472.

CLASSICS (CLASS)

Anthony J. Podlecki, *Head of the Department*
103 Ihlseng Building

Degree Conferred: M.A.

Graduate Faculty, Senior Members: Associate Professors Carrubba and Podlecki.

Programs leading to the master's degree in this field offer opportunities for specialization in either Latin or Greek, or a combination of both. The minimum requirement for admission to either program will normally be 18 undergraduate credits in either language. Provision is made, however, for admission with limited deficiencies. Candidates may either submit a thesis or schedule 6 additional credits in 500-level courses in the major field.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

GREEK (GREEK)

420. The Greek Historians (3)
421. Greek Tragedy (3)
422. Greek Comedy (3)
425. Homer (3)
430. The Greek Philosophers (3-9)
450. Topics in Greek Literature (3-6)
451. History of the Greek Language (3)
489. Studies in Greek Literature (1-6)

502. Greek and Latin Epigraphy (3) Study of the techniques of epigraphical research; the value of inscriptions for Greek and Roman history and private antiquities.

507. Problems in Greek Archaeology (3-9)

509. Greek Seminar (3-9)

517. Greek Research (1-6) Prosecution of an assigned problem under the guidance of a member of the department.

LATIN (LATIN)

420. The Latin Historians (3)
425. Latin Elegy (3)
426. Roman Comedy (3)
427. Vergil (3)
428. Lucretius (3)
430. Medieval Latin (3-6)
431. Roman Satire (3)
432. Roman Rhetorical and Literary Theory (3)
436. The Teaching of Latin (3)
437. Latin Prose Composition (3-6)
460. Topics in Latin Literature (3-6)
461. History of the Latin Language (3)
489. Studies in Latin Literature (1-6)

500. Latin Literature (3-9) Readings in the major forms of Latin literature; content varies, course may be repeated.

501. Roman Religion and Philosophy (3) Development of religious concepts at Rome from primitive Italic origins to the advanced forms that culminated in Roman Stoicism. Prerequisites: two 400-level courses in Latin.

510. Latin Seminar (3-6)

518. Latin Research (1-6) Prosecution of an assigned problem under the guidance of a member of the department.

*CLASSICS (CLASS)

401. The Classics and Archaeology (3)
405. Greek and Roman Mythology (3)
406. Emergence and Development of Classical Poetic Genres (3)
408. Greek Religion and Modern Man (3)
410. Classical Epic (3)
411. Classical Drama (3)
412. Classical Historians (3)
413. Readings in Classical Literature (3)

500. Introduction to Classical Scholarship (1-6) Lectures on the methods and materials of classical scholarship. To be scheduled by graduate students in their first term, and as necessary thereafter.

504. Topography of Ancient Rome (3) Lectures and readings on physical development of the ancient city of Rome from earliest habitation to time of later empire.

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* The readings are in English; knowledge of Greek and Latin is not required.

COMPARATIVE LITERATURE (C LIT)

Robert Lima
In Charge of Graduate Programs in Comparative Literature
N-346 Burrowes

Degrees Conferred: Ph.D., M.A.

Graduate Faculty, Senior Members: Professors Bayard, Hyslop, Lewis, Shelley, Weintraub, and West; Associate Professors Carrubba, Lima, and Rosenberg.

Graduate Faculty, Associate Members: Associate Professors Knight and Timpe, Assistant Professor Begnal.

Programs of study in international literary and cultural relations are arranged in accordance with the individual student's interests through a meaningful selection of courses both in comparative literature and in the several national literatures. Topics appropriate to such programs include the currency, reception, and influence of writers and works in countries other than those of their origin; the origin, transmission, and evolution of international literary movements; the characteristics and relations of genres, themes, and motifs; folk literature and folklore; criticism; aesthetics; intermediaries; relationships between literature and other disciplines.

In addition to the general requirements for graduate degrees, there are the following special requisites: *Master of Arts*—Courses in comparative literature (9 credits) and two national literatures (9 and 6 credits), knowledge of the language of each of the two literatures to be demonstrated by examination, a written examination, and a thesis (6 credits). *Doctor of Philosophy*—The language and communications requirement for the Ph.D. degree may be satisfied by courses in comparative literature (18 credits) and three national literatures, one of which may be English, (24, 12, and 12 credits), knowledge of the languages of each of the three literatures to be demonstrated by examination, a written examination and a doctoral thesis. Pertinent courses taken for the M.A. degree may be applied toward Ph.D. requirements.

Admission requirements to the program in comparative literature include an appropriate degree in literature or a related discipline, together with a strong background in at least one foreign language. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

COMPARATIVE LITERATURE (C LIT)

401. Western Literature I (3) — *Mrs. Eckhardt*
402. Western Literature II (3) — *Mr. Timpe*
403. Western Literature III (3) — *Mr. Begnal*
408. Heroic Epic and Song (3) — *Mr. Bayard*
420. Tradition in Modern African Literature (3) — *Mr. Michelman*
421. Modern African Literature: The Colonial Experience (3) — *Mr. Michelman*
443. (Ger. 443) Literary Relations of Germany with England and America (3-9) — *Mr. Shelley*
470. Old Masters of the Modern Novel (3) — *Mr. Begnal*
480. Introduction to Folklore (3) — *Mr. Rosenberg*
486. Tragedy (3)
487. Comedy (3)
488. (Engl. 488) Modern Continental Drama (3)
489. Special Subjects and Problems of Comparative Literature (3) — *Staff*

500. Seminar in Comparative Literature (3-6) *Staff*

501. Comparative Method in Literary Studies (3) *Mr. Timpe*

508. Norse and Gaelic Sagas (3) Medieval Irish and Scandinavian prose tales surveyed and compared with respect to backgrounds, development, themes, and characteristics. *Mr. Bayard*

570. Forces in Contemporary European Literature (3) The intellectual currents that have influenced European writers of the mid-twentieth century: Beckett, Böll, Robbe-Grillet, and others. *Mr. West*

588. Twentieth Century Drama (3) Translation and comparative analysis of previously untranslated plays. Prerequisite: fluent reading knowledge of a foreign language. *Mr. Lima*

593. (Engl. 593) Anglo-American Folk Song (3) Survey of relevant literary and ethnological scholarship and field work, European and American, from the early sixteenth century to the present. *Mr. Bayard*

COMPUTER SCIENCE (CMPSC)

Preston C. Hammer, *Head of the Department*
426 McAllister Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors deMaine, Gotterer, and Hammer; Associate Professors Coffman, Day, Laird, and Singletary.

Graduate Faculty, Associate Members: Associate Professors Barnes and Jones; Assistant Professors Campbell, Honkanen, Hosken, Hsu, Johnson, Squires, and Yntema.

The department offers courses and is prepared to direct research in a variety of subfields of computer science, including information retrieval, theoretical foundations of computer science, computer languages and programming systems, numerical analysis and nonnumeric procedures. The Computation Center has modern digital equipment and systems available for research and instruction.

Admission to the M.S. program without deficiency requires the equivalent of Cmp.Sc. 401 and 410 and at least four of the six following: (1) Cmp.Sc. 404, (2) Cmp.Sc. 411, (3) Cmp.Sc. 420, (4) Cmp.Sc. 453 or 454, (5) Cmp.Sc. 468, (6) Math. 63 and 441. The remainder of these six must be completed for the M.S. and Ph.D.

The M.S. candidate must satisfactorily complete Cmp.Sc. 510, 511, and 540, in addition to the other requirements of the Graduate School. The non-thesis option is available for the M.S. degree.

The Ph.D. degree is primarily a research degree, and is conferred on the basis of original work and high academic achievement in computer science. In order to be accepted as a candidate the student must pass a six hour written candidacy examination. The language and communications requirement for the Ph.D. degree may be satisfied by a proficiency in one foreign language (French, German, or Russian). These and additional requirements are detailed in the departmental brochure, *Computer Science at Penn State.*

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

COMPUTER SCIENCE (CMPSC)

401. Principles of Programming with Physical Science Applications (3)
402. Principles of Programming with Social and Biological Science Applications (3)
403. Principles of Programming with Business Applications (3)
404. Information Structures (3)
408. (Chem. 408) Computer Applications in Chemistry (3)
410. Introduction to Computer Systems (3)
411. Systems Organization and Programming (3)
420. The Structure of Programming Languages (3)
430. Combinatorics and Graph Theory (3)
450. Information Theory and Error-Correcting Codes (3)
453. (Math. 453) Numerical Computations (3)
454. (Math. 454) Matrix Computations (3)
468. Mathematical Machine Theory (3)
485. Introduction to Information and Language Structures (4)
490. Special Topics in Computer Science (1-9)
491. Computer Projects (3)

500. Theory of Automata (3) The structure of finite automata and sequential machines including characterization theorems, minimization problems, state identification experiments and decomposition theory. Prerequisite: Cmp.Sc. 468.

501. Algebraic Theory of Automata (3) Prerequisite: Cmp.Sc. 500.

510. Structure of Artificial Languages (3) Structure of problem-oriented languages; syntactical description, algorithms for translation, list structures, string manipulation, formula manipulation, relation to linguistics. Prerequisites: 3 credits in logic or logical design at the 400 level; Cmp.Sc. 420 or 485.

511. Systems Programming (3) Interpretive systems; assemblers, loaders, compilers, library monitor systems; input-output scheduling; executive programs, job scheduling; multiaccess systems, multiprogramming, multiprocessing. Prerequisite: Cmp.Sc. 404, 420, or 485.

530. Nonarithmetic Programming (3) Combinatorial problems, learning mechanisms, heuristic programs, and pattern recognition. Prerequisite: Cmp.Sc. 420 or 485.

535. Theory of Graphs and Networks (3) Theory and applications of graphs including structure of graphs, network analysis and algorithms for computer solution of graph-theoretic problems. Prerequisite: Cmp.Sc. 430.

540. Information Processing Systems (3) Data structures and data processing; information retrieval systems. Prerequisite: Cmp.Sc. 404 or 485.

545. Information Retrieval (3) This course deals with input-output, design implementation, evaluation, global memories and comparison of information retrieval systems. Prerequisite: Cmp.Sc. 540.

552. (Math. 552) Numerical Analysis I (3) Interpolation; remainder theory; approximation of functions; error analysis; orthogonal polynomials; approximation of linear functionals; functional analysis applied to numerical analysis. Prerequisites: Math. 420, 453.

553. (Math. 553) Numerical Analysis II (3) Eigenvalue and eigenvector determination; numerical solution of integral equations and ordinary differential equations with error and stability analysis. Prerequisites: Math. 420, 454 or 480.

560. Combinatorial Systems (3) The relationships among various forms of combinatorial systems including Turing machines, Post normal systems, Thue systems and recursive functions. Prerequisite: Cmp.Sc. 460.

563. (Math. 563) Aproximation Theory (3) Approximation in normed spaces; existence, uniqueness, characterization, computation of best approximations; error bounds, degree of approximation; approximation of linear functionals. Prerequisites: Math. 453, 501.

564. (Math. 564) Numerical Solution of Partial Differential Equations (3) Numerical solution of initial and boundary-value problems; eigenvalues and eigenfunctions; errors, stability, and convergence. Prerequisite: Math. 552.

566. (E.E. 566) Algebraic Coding Theory (3) Polynomial rings, galois fields, linear codes, cyclic codes, BCH codes, finite projective geometry cyclic codes, convolution codes, graph theoretic codes. Prerequisite: Cmp.Sc. 450 or E.E. 561.

568-569. Theory of Formal Languages and Automata (3 each) Generation and recognition of formal language, grammar, Chomsky's hierarchy of languages, closure properties, characterization by automata, algebraic properties, complexity classification. Prerequisite: Cmp.Sc. 468.

579. (Math. 579) Special Topics in Numerical Analysis (2-12)

590. Seminar in Computer Science (1-3) Topics from current research.

591. Special Topics in Computer Science (2-6)

592. Special Topics in Foundations (2-6)

593. Special Topics in Languages and Systems (2-6)

594. Special Topics in Nonnumerical and Self-improving Systems (2-6)

COUNSELOR EDUCATION (CN ED)

Edwin L. Herr
In Charge of Graduate Programs in Counselor Education
323 Social Sciences Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors Herr, Hudson, Hylbert, and Wellington.
Graduate Faculty, Associate Members: Associate Professors Britton and Kelz; Assistant Professors Swisher, Upcraft, and Warner.

Professional preparation is offered at the master's level for school counselors (elementary and secondary), college counselors or persons entering college student personnel services, and rehabilitation counselors. Doctoral programs prepare candidates for positions of responsibility and leadership in these same areas as well as in the education of counselors. Doctoral candidates must have a minimum of one year's work experience in their field.

The language and communications requirement for the Ph.D. degree may be satisfied by measured fluency in the reading, writing, and speaking of one foreign language together with courses from other designated areas.

All candidates for graduate degrees in counselor education must present for admission at least 27 undergraduate credits and a grade-point average of 3.00 in economics,

education, psychology, sociology, and physiology or anatomy with some credits in at least three of these areas. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. Doctoral candidates should present a 3.33 average in all graduate study completed and a satisfactory score on the Miller Analogies Test.

All candidates are expected to exhibit, in addition to academic competence, effectiveness in interpersonal relations and in both written and oral communication. They must also evidence support of professional counseling activities and organizations.

A candidate for either a Ph.D. or a D.Ed. must earn at least 30 credits in six or fewer consecutive terms in residence after completing the master's degree, preferably at the thesis planning and writing stage.

COUNSELOR EDUCATION (CN ED)

403. Foundations of Guidance and Counseling Processes (3)
404. Group Procedures in Guidance and Counseling (3)
408. Introduction to Vocational Rehabilitation (3)
409. Medical Information for Counselors (3)
410. Rehabilitation of the Mentally Ill (3)
412. Rehabilitation Facilities and Services of Pennsylvania (3)
413. Rehabilitation Case Recording and Management (3)

501. Counseling: Theory and Method (3) Theory and methods of counseling individuals whose problems of choice, decision, and adjustment fall within the normal range. Prerequisite: Cn.Ed. 403 or 408 or 551.

503. Guidance Services in Elementary Education (3) Guidance services to elementary school students; guidance opportunities for elementary teachers and principals. Prerequisite: Cn.Ed. 403.

504. Guidance Services in Secondary Education (3) Nature and scope of guidance in secondary schools—services, models, and strategies; the counselor as an agent of change. Prerequisite: Cn.Ed. 403.

505. Foundations of Counseling Information (3) Accelerating change in economic, psychological, social, educational influences upon counselees. Utilization of information systems in effecting counselee change. Prerequisite: Cn.Ed. 403 or 408 or 504 or 551.

506. Individual Analysis and Counseling Procedures (3) Collection and use of data basic to the counselor's understanding of individuals; the counseling interview and techniques other than testing. Prerequisites: Ed.Psy. 451 and Cn.Ed. 408 or 503 or 504.

507. Counseling Practicum (1-6) Practice in the application of guidance principles and methods to cases counseled under supervision; case conferences; seminar in guidance techniques. Prerequisite: Cn.Ed. 506.

508. Organization and Administration of Guidance Programs (3) Principles, organization, personnel, functions, integration with school programs, evaluation. Prerequisite: Cn.Ed. 506.

509. Contributions of Professional Personnel to Vocational Rehabilitation (3) Contributions of medical, social, psychological, and other specialists through the team approach; professional ethics, medical problems. Prerequisites: Cn.Ed. 403, 408.

511. Supervised Practicum in Rehabilitation Counseling (1-6) Application of principles and techniques of rehabilitation counseling to cases involving handicapped individuals. Prerequisites: Cn.Ed. 403, 408.

512. Professional Experience in Rehabilitation Counseling (1-6) Supervised internship with responsibility for a regular case load. Prerequisites: Cn.Ed. 403, 408.

513. Supervision of Counselors (3-9) Practical experience in supervising and evaluating work of counselors. Prerequisite: Cn.Ed. 507.

551. Student Personnel Services (2-3) Student personnel services in higher education; organization of student advisory programs; use of personnel data; co-curricular activities; student welfare.

553. Student Personnel Services Programming (2-3) Formulation of policies as guides to the student personnel service programs; integration of program elements; research; current problems and trends. Prerequisites: Cn.Ed. 551, Hi.Ed. 545.

589. Problems, Projects, and Area Studies in Counselor Education (1-6) Independent work in the study of topics in counselor education, or development of new curriculums, materials, or procedures for teaching.

591. Seminar in Counseling: History and Trends (1) Discussion of the history of guidance and counseling, emphasizing how the past has shaped the present and protends the future. Prerequisite: 9 credits in counselor education.

592. Seminar in Counseling: Legal and Ethical Concerns (1-2) Study and discussion of legal, ethical, and professional concerns of counselors; privileged communication, data banks, and privacy invasion. Prerequisite: 9 credits in counselor education.

593. Seminar in Counseling: Philosophy (1) Study and discussion of such philosophical foundations of counseling as phenomenology, idealism, realism, existentialism, daseinanalytic, theological, and other contemporary thoughts. Prerequisite: 9 credits in counselor education.

596. Seminar in Counseling, Guidance, and Rehabilitation (1-9) Conferences and discussions designed to meet the need for special study of particular topics in counseling, guidance, and rehabilitation. Prerequisite: 9 credits in counselor education.

597. Evaluation of Projects in School Guidance (2-6) Implementation and evaluation of program development projects in cooperation with state or local guidance programs. Prerequisite: 15 credits in counselor education.

DAIRY SCIENCE (D SC)

Donald V. Josephson, *Head of the Department*
111 Borland Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Almquist, Flipse, Josephson, Keeney, Kesler, McCarthy, Patton, and Watrous; Associate Professors Amann and Tanabe.
Graduate Faculty, Associate Members: Associate Professors Buckalew and Thoele, Assistant Professor Shellenberger.

Students may specialize in dairy products manufacture, chemistry of milk and dairy products, lipid metabolism, dairy cattle nutrition, dairy cattle genetics, dairy cattle management, and physiology of reproduction. The minor program is generally taken in biochemistry, microbiology, physiology, or agricultural economics. The language and communications requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Prerequisite to graduate work is the completion of an undergraduate major in animal industry, animal science, dairy science, food technology, or a related area. The undergraduate program must include college algebra and general physics. Students may be admitted with limited deficiency but are required to make up undergraduate deficiency work without degree credit.

Students with a 2.70 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.70 grade-point average may be made for students with special backgrounds, abilities, and interests.

DAIRY SCIENCE (D SC)

405. Dairy Cattle Management (3) *Mr. Buckalew*
418. Dairy Survey (1) *Mr. Shellenberger*
427. Milk Secretion (3) *Mr. Kesler*
428. Dairy Production Problems (1-6) *Mr. Kesler and Staff*
431. Physiology of Reproduction in Farm Animals (3) *Messrs. Almquist and Amann*

507. Dairy Cattle Management (1-6) *Mr. Kesler and Staff*

508. Dairy Seminar (1-6) Preparation and presentation of a paper on an assigned subject.

511. Dairy Cattle Nutrition (1-6) Nutritional requirements of dairy cattle. Prerequisite: A.Ntr. 401. *Mr. Kesler*

512. Advanced Studies in Milk Secretion (1-6) Physiology of milk secretion. Prerequisite: D.Sc. 427. *Mr. Kesler*

513. Dairy Cattle Breeding (1-6) Interpretation and application of current knowledge in genetics to dairy cattle breeding and selection. Prerequisites: An.Sc. 322, Biol. 422, 3 credits in statistics.

515. Advanced Physiology of Reproduction in Farm Animals (1-6) *Mr. Almquist*

516. Artificial Breeding of Farm Animals (1-6) Prerequisite: D.Sc. 431. *Mr. Almquist*

517. Dairy Science Literature (1-6) Review and reporting of dairy literature. *Staff*

521. Dairy Radiophysiology (3) Metabolism and physiology of radioactive compounds; their use as tracers in animal physiology and the effects of radiation on metabolic processes. Prerequisite: Chem. 405. *Mr. McCarthy*

Note: *See Animal Science under "Other Elective Graduate Courses." Also see Food Science.*

DEVELOPMENTAL AND REMEDIAL READING (D R R)

Arthur W. Heilman
In Charge of Graduate Program in Developmental and Remedial Reading
105 Rackley Building

Degree Conferred: M.Ed.

Graduate Faculty, Senior Members: Professors Bliesmer and Heilman.

The purpose of the master's program is to prepare classroom teachers in elementary and secondary schools for more effective teaching of reading and to provide preparation for supervisory and administrative positions relative to reading in school systems.

Candidates for a master's degree must meet the requirements for admission to graduate study and, in addition, (1) must hold, or be eligible to hold, a valid teaching certificate (persons not meeting this criterion may work on overcoming deficiencies; graduate credit, but not degree credit, may be received for graduate courses taken to overcome such deficiencies) and (2) must have had at least one year of teaching experience or the equivalent.

The master's program has been planned so that those completing the program will also meet the state requirements for "reading specialist" certification.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

DEVELOPMENTAL AND REMEDIAL READING (D R R)

441. Fundamentals of Reading Instruction (3)
442. Reading Problems in the Secondary Schools (2)
444. Practicum in Elementary Remedial Reading (3)
445. Practicum in Secondary Remedial Reading (3)
446. Remedial Reading in the Classroom (3)

546. Reading Instruction (3-6) Research, procedures and materials in reading readiness, word perception, basic reading skills, vocabulary development, reading in content subjects. Prerequisite: 6 hours of graduate credit in D.R.R.

557. Practicum: Remedial Procedures and Diagnosis (3-6) Advanced practicum; diagnostic testing and remedial instruction of more severe types of reading disability; newer and special materials and procedures. Prerequisite: D.R.R. 545.

559. Studies of Research in Reading (3) Intensive study of research in such areas as vocabulary; readiness; instructional approaches; rate; measuring capacity; readability; difficulty causes; sex differences. Prerequisite: 6 hours of graduate credit in D.R.R.

580. Studies in Developmental and Remedial Reading (1-6) Independent and intensive study of topics in reading which relate to research, instructional trends, new materials and total curricular programs. Prerequisite: 9 hours of graduate credit in D.R.R.

EARTH SCIENCES (EARTH)

E. Willard Miller
Chairman of the Committee on Earth Sciences
101 Mineral Sciences Building

Degrees Conferred: D.Ed., M.Ed.

Graduate Faculty, Senior Members: Professors Blackadar, Lewis, Miller, Panofsky, Thornton, Wernstedt, Williams, and Wright; Associate Professors Dutton and Weber.
Graduate Faculty, Associate Members: Associate Professors Guber and Lavoie; Assistant Professors Cuffey, Hovermale, and Lavin; Mr. J. Pena and Mrs. R. Pena.

The M.Ed. program is designed to meet the needs of science teachers in secondary schools. The fields of study are astronomy, geography, geology, geophyics, meteorology, and mineralogy. The student selects one of the earth sciences as an area of concentration, takes at least 12 credits in it, and is required to write a term paper in that area. An additional 12 credits must be taken in at least two other fields of earth sciences, or in two earth science fields plus two courses selected from the biological sciences, chemistry, mathematics, or physics. Furthermore, 6 credits in educational foundations are required as a minor.

The D.Ed. program is designed for secondary school and college science teachers. The major course requirements are designed by the candidate's committee with one area of concentration in the earth sciences plus courses from at least two other earth science areas. The program is designed to investigate problems which arise from the complex interaction of man's technological and social activities with the natural environment. A minimum of 15 credits each is required in professional education and in thesis research.

Students with a 2.50 junior-senior average, 18 credits in education and related psychology, and with other appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

The following courses offered by the various departments are appropriate for students majoring in the earth sciences: Astro. 430; Geog. 433, 434; Geol. 400, 401, 402; Gphys. 400; Meteo. 400, 401, 402, 403, 404; Min. 402.

EARTH SCIENCES (EARTH)

400. Earth Sciences Seminar (3)

500. Earth Sciences Research (1-6) Relationships between the earth sciences revealed by theory, analytical methods, or a selected problem.

ECONOMICS (ECON)

Grant N. Farr, *Head of the Department*
613 Graduate Building

Degrees Conferred: Ph.D., M.A., M.Ed.

Graduate Faculty, Senior Members: Professors Budd, Coppock, Farr, Kaufman, Klein, Mason, Newman, Prybyla, Robinson, Rozen, and Stout; Associate Professors Hu, Long, Riew, and Smith.

ECONOMICS

Graduate Faculty, Associate Members: Associate Professors Feller, Herendeen, and Sauerlender; Assistant Professors Booms, Bradley, Cohn, Fox, and Friedrich.

Opportunities are available for concentration in the following fields: economic analysis, economic doctrines, economic development of develcped areas, economic development of underdeveloped areas, economic fluctuations, income distribution, industrial organization, international economics, comparative economic systems, labor economics, money and banking, public finance, quantitative economics, statistics, and regional economics.

Students may also qualify for admission to the program in population issues consisting of interdisciplinary course work with special emphasis on the economic, social, and geographic issues arising from the dynamics of population change. The language and communications requirement for the Ph.D. degree may be satisfied by an intermediate knowledge of two foreign languages, by substitution of courses from other designated areas for one of these languages, or by a comprehensive knowledge of one foreign language.

The department may waive the requirement of a thesis for M.A. candidates.

To enter graduate work in economics a student should have completed 6 credits in economic principles, 9 in the social sciences, and either 3 in statistics or 6 in mathematics. All applicants must take the Graduate Record Examination in advanced economics and general aptitude.

Students with a 2.50 junior-senior average, a 3.00 average in courses in economics, and appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

ECONOMICS (ECON)

400. History of Economic Thought I (3)
401. History of Economic Thought II (3)
404. Current Economic Issues (3)
405. Advanced Economic Analysis (3)
412. Economics of Collective Bargaining (3)
413. (L.S. 413) Comparative Labor Movements (3)
414. (L.S. 414) Theories of the Labor Movement (3)
415. Social Insurance (3)
418. Economics of Wages and Employment (3)
419. Case Studies in Labor-Management Relations (3)
423. State and Local Taxation (3)
427. (Ed.Adm. 427) Economics of Education (3)
429. Advanced Public Finance (3)
433. International Monetary Economics (3)
435. Labor Relations in the Public Sector (3)
442. Monopoly, Competition, and Their Regulation (3)
450. The Business Cycle (3)
451. Monetary Theory and Policy (3)
461. Economic Growth: Underdeveloped Areas (3)
462. Economic Growth: Theories of United States Development (3)
480. Mathematical Economics (3)
489. Selected Topics in Economics (3)
490. Introduction to Econometrics (3)
491. Analysis of Linear Economic Models (3)
499. Foreign Study in Economics (2-6)

500. Economic Seminar (3-6)

502. Microeconomic Analysis (3) Economic behavior under pure and imperfect competition; price and output determination in product markets; prices and employment in factor markets.

503. Macroeconomic Analysis (3) National income accounts; determination of income, employment, interest rates, and the price level; stabilization policy.

506. Problems in Economics (3-6) Planned individual projects involving library, laboratory, or field work.

507. International Trade (3) A survey of international trade theory including modern developments of pure theory, and of international trade policy.

508. Current Monetary Theory and Policy (3) Post-Keynesian reformulation of quantity and Keynesian theories of money; liquidity and general equilibrium approaches; current issues in theory and policy.

510. Econometrics (3-6) Statistical estimation in mathematically formulated economic relationships.

512. Wage Determination (3) Development of wage and employment theory; structure of labor markets; impact of unions on income distribution, price level, and employment.

513. Development of Economic Doctrines (3-6)

515. Economics of the Labor Market (3) Theory and problems of labor-management relations; selected problems of the labor market with reference to current research and developments.

516. Economics of Human Resources (3) Analysis of changes in human resource supply and demand; factors affecting these changes; current human resource policies.

517. International Finance (3) Problems of international liquidity; balance of payments adjustment; international financial institutions and selected policy problems.

518. Development of Monetary Theory (3) Classical and neoclassical quantity theories of money and contemporary criticism; Keynesian monetary theory and its critics.

521. Advanced Microeconomic Theory (3-6) Theory of consumer behavior; theory of the firm; price determination in product and factor markets; introduction to welfare economics.

522. Advanced Macroeconomic Theory (3-6) Measurement of income; theories of consumption, investment, and money holdings; static determination of income and employment; introduction to dynamic analysis.

524. Income Distribution (3) Measurement of inequality; ethical issues in income redistribution; measurement and determination of distributive shares; problem of poverty.

525. Economics of Technological Change (3) Theoretical and empirical analysis of invention and innovation and their effects on productivity, employment, and market structure.

528. Advanced Economic Theory: Selected Topics (3) Treatment of topics in economic theory to meet needs of advanced students seeking intensive work in selected areas.

529. Public Finance (3-6) Contemporary problems in public finance; instruments of fiscal policy in the achievement of full employment, price stability, and economic development.

530. Regional Microeconomics (3) Theoretical and empirical analysis of industrial location as determined by costs, markets, and agglomeration effects.

531. Regional Macroeconomics (3) Aggregate regional trade flows; sources of regional economic data; techniques for measuring regional economic activity; long-run regional growth.

543. Industrial Organization and Public Policy (3) The structure of American industry; performance and behavior; public policies toward business.

550. Economic Fluctuations (3) Analysis of the various theories of economic fluctuations; their methodological premises.

551. Stabilization Policy (3) Description and analysis of the alternatives and issues in stabilization policy.

560. Seminar in Economic Growth: Underdeveloped Areas (3-6) Resources and institutions; quantitative measures; theories of economic growth in developing areas; developmental policies.

561. Seminar in Economic Growth: Developed Areas (3-6) Growth models; strategic factors in growth; quantification problems; public policy.

571. Comparative Economic Systems (3-6) Comparative analysis of alternative resource allocation principles; growth and performance of different economic systems; problems of decision making and control.

572. Soviet and Other Centrally Planned Economics (3-6) Principles, structure, and performance of centrally planned economies with special emphasis on the Soviet Union.

580. Mathematical Economics (3-9) Mathematical development of static and dynamic economic models: partial and general equilibrium analysis; growth dynamics; mathematical programming. Prerequisite: Econ. 480.

595. Seminar in Econometric Theory (3-6) Advanced study in the theories and problems relevant to the application of statistical methods to economics. Prerequisites: 6 credits of Econ. 510 and Math. 409.

EDUCATION OF EXCEPTIONAL CHILDREN (E E C)

Robert M. Smith
In Charge of Graduate Programs in Education of Exceptional Children
120 Special Education Building

Degrees Conferred: Ph.D., D .Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors Bliesmer, French, Heilman, McDonald, Siegenthaler, and Smith; Associate Professors Anderson and Frick.

Graduate Faculty, Associate Members: Associate Professors Berlin and Cartwright.

Exceptional children are those who deviate so far from average in physical, intellectual, emotional, or social characteristics that they cannot profit adequately from

the usual public school program. It is the purpose of this program to prepare teachers, researchers, administrators, and college and university teachers in the areas encompassing the education of the mentally retarded, gifted, emotionally maladjusted, neurologically impaired, learning disabled, or crippled. A multidisciplinary approach is emphasized. The language and communications requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign languages.

Prerequisites for a master's program include: 10 credits in the education of exceptional children (courses comparable to E.E.C. 400, 401, 403, and 405).

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Applicants for doctoral study shall show evidence of (1) having completed a master's degree with "A" quality grades on at least one-third of the graduate courses and (2) attaining a minimum score of 500 on both portions of the Graduate Record Examination, or 50 on the Miller Analogies Test, or 35 on the Quantitative Educational Device.

EDUCATION OF EXCEPTIONAL CHILDREN (E E C)

400. Introduction to Exceptional Children (3)
401. Educational Adjustments for Exceptional Children (3)
403. Clinical Teaching with Exceptional Children (3)
405. Practicum in the Education of Exceptional Children (1-12)
410. The Mentally Retarded (3)
420. The Mentally Gifted (3)
440. (S.P.A. 440) Survey of Speech and Hearing Disorders (3)
444. Reading Disabilities (2-3)
445. Techniques in Remedial Reading (2-6)
454. Diagnosis of Educational Disabilities (3)
470. The Emotionally Disturbed (3)
472. Educational Problems of Urban Alienated Youth (3)
480. The Neurologically Impaired (3)
496. Workshop in Special Education (1-9)

500. Seminar in Special Education (1-9) Continuing series of professional seminars designed to provide a forum for discussion of current and classical research concerning exceptional children. Prerequisites: Ed.Psy. 400 and 6 credits in education of exceptional children.

501. Administration and Supervision of Educational Programs for Exceptional Children (2-3) Problems connected with the instituting and organizing of classes for atypical children; the legal phases, finances, teaching personnel, pupil personnel, housing, equipment, courses of study, curriculum, etc. Prerequisites: E.E.C. 401 and Ed.Ser. 480 or teaching or administrative or supervisory experience.

502. Internship in Special Education (2-10) Internship to take place in schools or educational situations where student is not regularly employed, under supervision of graduate faculty. Prerequisite: E.E.C. 405 or teaching experience.

509. Problems, Projects, and Area Studies in Special Education (1-9) May not be used for thesis credit. Prerequisite: 12 graduate credits in special education.

510. Problems in the Education of the Mentally Retarded (2-4) Study of existing curriculums, instructional practices, educational programs; experimentation

in curriculum building and materials construction. Prerequisites: teaching experience and E.E.C. 410.

520. Problems in the Education of the Mentally Gifted (2-4) Analysis of educational needs of mentally gifted; curriculum construction and curricular materials. Prerequisites: teaching experience and E.E.C. 420.

545. (S.P.A. 545) Cerebral Palsy (3) Etiology and symptomatology of cerebral palsies; diagnosis and treatment of communication problems; the multiprofessional habilitative program. Prerequisite: S.P.A. 444.

546. Aphasia and Allied Disorders (3) Aphasia and related disorders in adults and children: etiology, diagnosis, and treatment. Prerequisite: S.P.A. 444.

547. (S.P.A. 547) Language Disorders in Children (2) Nature, etiology, diagnosis, and management of language disorders in children. Prerequisite: 9 credits in speech pathology and audiology or related fields such as psychology, linguistics, or human development.

554. Psychological and Educational Evaluation of Exceptional Children (3) Administration and interpretation of individual tests other than the Stanford-Binet, WISC, WAIS. Prerequisite: Psy. 559.

570. Problems in the Education of the Emotionally Disturbed (2-4) Prerequisite: E.E.C. 470.

572. Seminar in the Education of Alienated Groups (2) A study of the alienated and educational issues of coping with problems of social, cultural, and economic deprivation. Prerequisite: E.E.C. 472.

573. Problems of Research with Alienated Groups (2) A seminar to review and design research studies for the education and training of alienated groups. Prerequisites: E.E.C. 472, 572.

580. Problems in the Education of the Neurologically Impaired (2-4) Prerequisite: E.E.C. 480.

EDUCATIONAL ADMINISTRATION (EDADM)

Patrick D. Lynch
In Charge of Graduate Programs in Educational Administration
222 Rackley Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors DeLacy, Lutz, and Willower.
Graduate Faculty, Associate Members: Professor Lynch, Associate Professors Caldwell and Kohl.

Professional preparation programs are offered at the master's and doctor's degree levels for elementary and secondary school personnel whose objectives are to become principals, supervisors, superintendents, state education department personnel, professors of educational adminstration, and/or researchers in educational administration.

The language and communications requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign languages.

Requirements for admission to a graduate program in educational administration include 18 approved undergraduate credits in education and psychology. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

All candidates who seek M.Ed. and M.S. degrees in educational administration shall complete programs embracing a minimum of 30 graduate credit hours. In only rare instances, however, to fulfill unusual objectives will candidates be permitted to work toward the M.S. degree.

Candidates for the D.Ed. and Ph.D. degrees are required to complete a minimum of three consecutive terms in residence.

From the time of initiation of a 600-level thesis research program, all doctoral candidates shall continuously register for a minimum of 2 credits per term until the termination of the graduate program. Failure to register for doctoral thesis credits in any term shall be considered automatic withdrawal. Specific requirements with respect to the Ph.D. and D.Ed. degrees may be learned from a departmental bulletin that is available upon request. Although candidates are required to specialize in a field of educational administration, they are also encouraged to acquire a general education in the social sciences, the behavioral sciences, and the humanistic foundations.

EDUCATIONAL ADMINISTRATION (EDADM)

427. (Econ. 427) Economics of Education (3)
460. Introduction to Adult Education (3)
480. Educational Administration (2-3)
481. Collective Negotiations in Public Education (3)

528. (Pl.Sc. 528) Politics and Education (3) Social forces which shape the educational system and determine national, state, and local educational policies.

533. The Politics of Local School Districts (3) The methodology of studying political decision making and the theory and practice of politics in local school districts. Prerequisite: 6 credits of sociology, anthropology, or political science.

565. Personnel and Grievance Administration (2-3) Practice and theory of personnel supervision at the central office and building level, including contract administration and grievance handling. Prerequisites: 18 credits in education and three years' teaching experience.

567. Organizational Supervision (3) The organizational context of the school, its relationship to supervision, and the improvement of instruction. Prerequisites: Ed.Adm. 480 and teaching experience.

568. The Principalship (2-3) For elementary and secondary principals. The administrative and management tasks of building administration. The social system, change, and community relationships.

569. Principalship Seminar (2-3) The study and application of interdisciplinary based products and processes in the various organizational units within the educational system.

571. The Educational Plant (2-3) School plant needs in terms of school population and curriculums; the building survey, developing a plant program, the building site, plant utilization, operation and maintenance, heating and ventilation, equipment, school building costs and finance. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.

572. Public Relations for School Administrators (2-3) School-community relationships; social structure, social change, and the schools; case studies of community-school problems. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.

573. Public School Finance (2-3) Financing of public education in relation to organization and control; the conceptual basis for local financial administration; taxation, state and federal aid, school revenue, and money management. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.

574. Theory and Practice of Educational Negotiations (2-3) Theoretical framework, bargaining strategies, legislation, administrative roles, agreements, etc. Prerequisites: Ed.Adm. 480 or teaching or administrative or supervisory experience, and previous work in school administration.

575. Administration of Adult Education in the Public Schools (3) The organization of a program of adult education; its legal status, finances, selection of teachers, learning personnel, housing, and other administrative problems connected with adult education. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.

576. Legal Aspects of School Administration (3) Legal bases for the organization and administration of school districts and schools; the powers, rights, privileges, and responsibilities of school corporations, school boards, administrators, and personnel; the law and fiscal policies; the course of study, textbooks; contracts; taxes, torts; records; agents; and the judicial decisions involved. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.

578. Dynamic Factors in School Administration (2-3) Intraorganizational relationships; administration and the school as a social system; formal and informal organization. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.

579. Public School Business Administration (2-3) Business management applied to school management problems; budgeting, accounting, purchasing, insurance, school equipment, cafeteria management; transportation, salaries, personnel management, and auxiliary and coordinate agencies. Prerequisites: Ed.Adm. 480 or teaching or administrative or supervisory experience; Ed.Adm. 573.

580. The Use of Theory in Educational Administration (1-6) Administrative theories applied to educational organizations. Prerequisites: Ed.Adm. 480, 6 credits in educational administration.

581. Field Research in Educational Administration (2-3) Methods of appraisal of an educational program; planning for expansion, consolidation, or reduction of educational offerings. Prerequisites: Ed.Adm. 480, 6 credits in educational administration.

582. Internship in Administration and Supervision (1-12) Internship to take place in schools or educational situations where student is not regularly employed, under supervision of graduate faculty.

589. Problems, Projects, and Area Studies in Educational Administration (1-6) Independent work in the study of topics in educational administration, or development of new curriculums, materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of the department head.

591. Seminar in Public School Research (1-4) Doctoral candidates present outlines of their theses to the Graduate Faculty of the department and advanced graduate students.

596. Seminar in Education (1-9) Conferences and discussions designed to meet the need for special study of particular fields in education. Prerequisite: 12 credits of graduate work in education.

597. Workshop in Current Educational Problems (1-6) For administrators, supervisors, experienced elementary and secondary teachers, guidance workers; administrative, supervisory, and instructional problems involved in an emerging educational program. Prerequisite: 12 credits of graduate work in education.

EDUCATIONAL PSYCHOLOGY (EDPSY)

William Rabinowitz, *Head of the Department*
201 Social Sciences Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors DiVesta, French, Games, Lathrop, Mitzel, Rabinowitz, Thevaos, and Withall; Associate Professors Impellitteri and Seibel; Mr. Greenhill.

Graduate Faculty, Associate Members: Associate Professors Hall, Snyder, and Weener; Assistant Professors Johnson, Sanders, and Schwartz.

Graduate work is offered in the general field of educational psychology. Students may specialize and do research in school learning, educational and psychological measurement, statistics and research design as applied to education, and the psychology of instructional systems. Other areas of study related to educational psychology, such as counseling and guidance, clinical psychology, and special education, are offered in other departments of the University.

Doctoral degree requirements include a major emphasis in one of the above areas of educational psychology with minor emphasis in two related areas (one being in this department). Typically, the doctoral program of study would include at least one course in each of the following areas: research methods, educational and/or philosophical foundations, computer science, human learning, instructional media, measurement, social or industrial psychology, clinical psychology, experimental psychology, and developmental psychology. The language and communications requirement for the Ph.D. degree may be met by demonstrating competency in two of the following areas: foreign languages, computer techniques, philosophy of science, and technical writing.

Special facilities include a research design laboratory, a laboratory for computer-assisted instruction, a self-instruction media laboratory, facilities for film production and editing, and a closed-circuit television studio in Chambers Building used for both research and instruction. Facilities in other departments available to students majoring in educational psychology are the Nursery School, the Psychology Clinic, the Reading Center, the Special Education Center for Children, the Division of Instructional Services, and the Speech and Hearing Clinic. The Computation Center, with several computer systems, is available for use in graduate student research.

Students with a 3.00 junior-senior average and a broad undergraduate background including some college mathematics will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Applicants are required to submit scores on either the Graduate Record Examination or the Miller Analogies Test. Applicants with a master's degree will be required to show more than minimum success in graduate study, including at least one-third of their graduate credits of "A" quality.

EDUCATIONAL PSYCHOLOGY (EDPSY)

400. Statistical Interpretation of Educational Research (2)
406. Applied Parametric and Nonparametric Statistics in Education (3)
407. Regression and Correlation Methods for Educational Data (2)
421. Learning Processes in Relation to Educational Practices (3)
450. (Psy. 450) Principles of Measurement (3)
451. Appraisal and Interpretation of Standardized Group Tests (2)
475. Introduction to Educational Research (2)
476. Experimentation in Educational Psychology (3)

501. Current Topics in Educational Psychology (2-6) Study of the current literature in educational psychology with emphasis on historical and theoretical aspects of important areas of investigation. Prerequisites: Ed.Psy. 406, 450, and 421.

506. Advanced Techniques for Analyzing Educational Experiments (3) Advanced techniques for research in education; analysis of covariance; repeated measures; randomized block designs; Latin square; and other experimental arrangements. Prerequisites: Ed.Psy. 406 and 407, or Psy. 415.

507. Multivariate Procedures in Educational Research (3) Introduction to matrix algebra, computer programming, multiple regression analysis, multiple and canonical correlation, multiple discriminant analysis, classification procedures, factor analysis. Prerequisites: Ed.Psy. 406 and 407, or Psy. 415.

512. Group Processes in the Classroom (2) Basic concepts and perspectives in the study of group processes; instructional group interaction; analysis of classroom behavior.

513. Individual and Group Differences (2) Historical and contemporary attempts to relate individual differences to important social and educational issues. Prerequisite: Ed.Psy. 400 or Psy. 15.

519. Psychological Foundations for College Teaching (2) Psychological, sociological, and organizational variables which influence college student behavior. Designed for graduate students who anticipate careers in college teaching.

520. Application of Learning Models to Classroom Practices (2) Probabilistic models of acquisition in complex human learning; assessment of learning in the classroom that is amenable to such analysis. Prerequisite: Ed.Psy. 421.

522. Concept Learning in the Schools (2) Study of theory and research related to concept formation and attainment with implications for instruction. Prerequisite: Ed.Psy. 421.

523. Problem Solving in the Schools (2) Examination of theory and research related to cognitive processes in problem solving with implications for educational practice. Prerequisite: Ed.Psy. 421.

524. Theories of Learning and Instruction (3) Study of major classical theories of learning and recent developments in learning and instructional theory. Prerequisite: Ed.Psy. 421.

530. Theory and Research in Programmed Learning (3) Research and trends in programmed learning; preparation of short programmed sequences for experimental analysis. Prerequisites: Ed.Psy. 450 and 421, or Psy. 404.

532. Survey of Media Research (3) Systematic study of media research in educational applications of television, still and motion pictures, graphic and simulated environments. Prerequisite: Ed.Psy. 400 or Psy. 415.

550. Design and Construction of Psychological Measures (3) Lecture-practicum involving planning, construction, administration, and analysis of a psychological test; lectures stress construct validity, item analysis, and predictive validity. Prerequisite: Ed.Psy. 450.

554. Theories of Psychological Measurement (2) Basic true-score and error models; their extensions to test reliability and test validity; problems of item analysis and weighting. Prerequisite: Ed.Psy. 450.

558. Scaling Educational and Psychological Measures (2) Unidimensional and multidimensional scaling models with emphasis on psychometric methods and brief attention to psychophysical methods. Prerequisite: Ed.Psy. 450.

575. Seminar in Educational Psychology (3-9) A seminar dealing with specific topics in educational psychology. Open to advanced students in the behavioral sciences.

591. Problems and Projects in Educational Psychology (1-6) Independent work on special topics.

ELECTRICAL ENGINEERING (E E)

William J. Ross, *Head of the Department*
118 Electrical Engineering East

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Brown, Cross, Ferraro, Hale, Holt, Lewis, Mentzer, Nisbet, Ross, and Volz; Associate Professors Adams, Das, Etzweiler, Lachs, Lee, McMurtry, and Quinn; Assistant Professor Bredeson.

Graduate Faculty, Associate Members: Adjunct Professor Jeffreys; Associate Professor Robinson; Assistant Professors Bishop, Delansky, and Hulina.

Course offerings and research facilities are available in the following areas: antennas, communications systems (conventional and laser), computers (including digital, analog, hybrid, and network analyzer), control systems, energy conversion and distribution, electron devices, information theory, ionosphere research (geomagnetism and aeronomy), microwave theory and techniques, networks, plasmas and MHD, power system analysis, solid state devices, servomechanisms, and wave propagation.

The language and communications requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

A bachelor's degree in engineering or science is required with courses in electrical circuits, fields, and electronics. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

ELECTRICAL ENGINEERING (E E)

401. Network Analysis for Technology Teachers (3)
402. Electronic Devices and Circuits for Technology Teachers, Part I (3)
403. Electronic Devices and Circuits for Technology Teachers, Part II (3)
404. Electromechanical Energy Conversion for Technology Teachers (3)
405. Electronic Instrumentation for Nonelectrical Engineers and Scientists (3)

411. Principles of Electromagnetic Fields (3)
413. Linear Network Analysis (3)
417. System Theory (3)
418. Solid State Device Technology (3)
419. Solid State Devices (3)
421a,b,c,d. Electrical Engineering Problems (1-10)
425. Symmetrical Components (3)
428. Linear Control Systems (3)
429. Control System Design (3)
432. Microwave Methods and Analysis (3)
435. Engineering Analysis (3)
437. Engineering Applications of Complex Variables (3)
438. Antenna Engineering (3)
441. Active Circuits (3)
448. Linear Electronic Design (3)
449. Digital Electronic Design (3)
450. Network Analysis (3)
459. Introduction to Statistical Theory of Communications (3)
461. Fundamentals of Power System Stability (3)
470. Electronic Analog Computers (3)
471. Logical Design of Switching Systems (3)
472. Introduction to Digital Subsystems (3)
490. (Nuc.E. 490) Introduction to Plasma Theory (3)
491. Plasma Phenomena and Diagnostic Laboratory (3)

514. Quantum Electronics (3) Quantization of electromagnetic fields; quantum statistics of attenuators and amplifiers; analysis of laser oscillators; Glauber P-representation; photon detection and coherence. Prerequisite: Phys. 561.

519. Semiconductor Devices (3) Characteristics and limitations of bipolar transistors, diodes, transit time and bulk-effect devices. Prerequisite: E.E. 419.

520. Seminar (1) Required of all graduate students in electrical engineering. Conferences, reading, and presentation of technical papers.

521. Advanced Electrical Engineering Problems (1-10)

523. Nonlinear Analysis (3) Transient and steady state analysis of nonlinear physical systems; phase plane analysis, iterative techniques, singular points, and subharmonics. Prerequisite: E.E. 435.

525. Symmetrical Components (3) Polyphase circuits and machines under unbalanced conditions of operation including effects of rotating machines upon distribution and transmission system performance; characteristics of phase converters and single-phase operation of polyphase systems. Prerequisite: E.E. 425.

527. Linear Control Systems (3) Continuous and discrete-time linear control systems; state variable models; analytical design for deterministic and random inputs; time-varying systems stability. Prerequisite: E.E. 428 or M.E. 455, E.E. 417.

528. Nonlinear Control and Stability (3) Design of nonlinear automatic control systems; phase-plane methods; describing functions; optimum switched systems; Liapunov stability; special topics in stability. Prerequisites: E.E. 428 or M.E. 455, E.E. 417.

529. Optimal Control (3) Variational methods in control system design; classical calculus of variations, dynamic programming, maximum principle; optimal digital control systems; state estimation. Prerequisite: E.E. 527.

530. Adaptive and Learning Systems (3) Adaptive and learning control systems; system identification; performance indices; gradient, stochastic approximation, controlled random search methods; introduction to pattern recognition. Prerequisite: E.E. 527.

532. Advanced Microwave Engineering (3) Theory of wave guides and discontinuities, resonant cavities, traveling wave oscillators and devices; interaction of fields with matter. Prerequisites: E.E. 432 and 411.

535. Engineering Analysis (3) Applications of mapping methods, series and integral representations to the solution of boundary value problems in electrical engineering. Prerequisite: E.E. 437.

536. Transform Methods in Linear Analysis (3) Analysis of linear systems by Laplace transform with emphasis on periodic nonsinusoidal forcing functions. Prerequisite: E.E. 435.

538. Electromagnetic Engineering (3) Electromagnetic fields using the Maxwell-Lorentz equations as applied to vector fields, special solutions to scattering, diffraction, and radiation problems. Prerequisite: E.E. 411.

539. Antenna Engineering (3) Boundary value problems of radiating structures, integral equation formulations, source excitation problems, reflector antennas. Prerequisites: E.E. 411, 438.

546. Field-Effect Devices (3) The physical background, characteristics and limitations of surface field-effect and junction field-effect devices and related structures. Prerequisite: E.E. 419.

547. Dielectric Devices (3) Applications of insulator physics and devices based on insulator properties. Prerequisite: E.E. 419.

548. Linear Integrated Circuits (3) Design of monolithic, thin-film and hybrid linear integrated circuits; D.C., video, tuned, r.f. and microwave applications. Emphasis on reliability. Prerequisites: E.E. 418, 448.

550. Network Synthesis (3) Positive real functions, realizability conditions, synthesis of driving point immittances, synthesis of two-terminal pair networks, transfer function synthesis. Prerequisites: E.E. 437, 450.

560. Statistical Theory of Communications (3) Generalized harmonic analysis; the application of correlation and convolution to the detection of signals in noise; various special topics. Prerequisite: E.E. 459 or Math. 409.

561. Information Theory (3) Mathematical measurement of information; information transfer in discrete systems; redundancy, efficiency, and channel capacity; encoding systems. Prerequisite: E.E. 459 or Math. 409.

562. Detection Theory (3) Detection decision theory, Bayes and Neyman-Pearson criteria, optimal receivers, classical estimation theory, signal-noise representations, optimum linear signal parameters estimation. Prerequisite: E.E. 560.

566. (Cmp.Sc. 566) Alegbraic Coding Theory (3) Polynomial rings, galois fields, linear codes, cyclic codes, BCH codes, finite projective geometry cyclic codes, convolution codes, graph theoretic codes. Prerequisite: Cmp.Sc. 450 or E.E. 561.

569. Simulation of Biomedical Systems (3) Simulation of biological and medical systems on analog and digital computers; direct electrical analogs; modeling techniques. Prerequisites: E.E. 470 or Cmp.Sc. 401 and Biol. 11.

570. Advanced Electronic Analog Computers (3) Advanced techniques of analog computation and simulation; machine and problem errors; nonlinear differential equations. Prerequisite: E.E. 470.

571. Digital Computers: Recent Developments and Advanced Logic (3) Advanced treatment of logical design; discussion of topics of current interest in the general area of digital computers. Prerequisite: E.E. 471.

572. Digital System Design (3) Complete digital system design including specification, internal organization, and realization. Discussion of interaction among digital systems and subsystems. Prerequisite: E.E. 472.

580. Radio Waves and the Ionosphere (3) The magneto-ionic theory of ionospheric wave propagation; ray-optical approximations; determination of ionization profiles; full wave solutions; nonlinear and coupling effects. Prerequisite: E.E. 62 or 438 or Phys. 557.

581. Constitution of the Ionosphere (3) Properties of neutral and ionized atmosphere above 60 km; photochemical processes; solar, meteoric perturbations of the ionosphere; large-scale movements in ionization.

590. (Nuc.E. 590) Theory of Plasma Waves (3) Solutions of the Boltzmann equation; waves in bounded and unbounded plasmas; radiation and scattering from plasmas. Prerequisite: E.E. 490.

591. (Nuc.E. 591) Plasma Theory (3) Advanced topics in kinetic theory, fluctuation theory, microinstability, and turbulence. Prerequisite: E.E. 590.

ELEMENTARY EDUCATION (EL ED)

Paul W. Bixby
In Charge of Graduate Programs in Elementary Education
168 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors Bixby, Bliesmer, Brewer, Corle, Heilman, and McAulay; Associate Professor Zafforoni.

Graduate Faculty, Associate Members: Professor Alessandro, Associate Professor Alfke and Suydam, Assistant Professors Shrigley and Trueblood.

The graduate programs provide advanced professional preparation for early childhood and elementary school teachers, curriculum specialists, elementary supervisory personnel, elementary school principals, and elementary teacher education personnel.

The language and communications requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign languages.

For admission 18 credits in elementary education and teaching experience are required. Students with a 2.70 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.70 grade-point average may be made for students with special backgrounds, abilities, and interests.

The Master of Education degree in elementary education is offered also at the Capitol Campus. Specific requirements may be found in the *Capitol Campus Catalog.*

ELEMENTARY EDUCATION (EL ED)

426. Problems of Elementary School Arithmetic (2-3)
431. Contemporary Elementary School Mathematics Programs (2)

433. Teaching Social Studies in the Elementary Grades (2-3)
435. Field Natural History for Teachers (3)
436. Teaching of Conservation of Natural Resources in the Elementary School (3)
437. Teaching of Conservation of Natural Resources in the Elementary School (3)
438. Teaching Science in the Elementary School (1-3)
443. The Elementary School Reading Program (3)
449. Teaching Children's Literature (2-3)
453. Special Problems in the Teaching of Elementary School English (2-3)
461. Elementary Education (2-3)
467. School Programs for Young Children II (3)
479. Measurement of Achievement in the Elementary School (2-3)
485. Workshop in Selected Studies in Elementary Education (1-6)

511. Supervision of Student Teachers (3) A course in supervision for master teachers, department heads, and college teachers with supervisory responsibilities in teacher education. Prerequisites: teaching experience and 18 credits in education, including at least 5 in methods.

520. Internship in Elementary Education (3-6) Internship to take place in schools or educational situations where student is not regularly employed, under supervision of Graduate Faculty.

526. Applications of Research in the Teaching of Elementary School Mathematics (3) Research applications dealing with the study of curriculum, materials, evaluation, teaching, learning, and supervision of elementary school mathematics. Prerequisites: El.Ed. 426 and elementary teaching experience; Ed.Psy. 400.

533. Problems and Issues in Elementary School Social Studies (3) Historical-philosophical bases for the social studies: curriculum development, research findings and techniques, learning resources, and promising proposals. Prerequisites: El.Ed. 433 and elementary school teaching experience.

562. Problems of Elementary Education (2-3) Problems seminar for experienced educators. Prerequisite: 12 credits in education and psychology, including 6 in elementary education.

563. Seminar in Contemporary Issues in Elementary Education (1-3) Conferences and discussions designed to meet the needs of experienced teachers and principals in the field of elementary education. Prerequisites: 6 credits in elementary education and teaching experience.

564. Organization of the Elementary School Curriculum (2-3) Principles underlying curriculum construction. Primarily for elementary education majors. Prerequisite: El.Ed. 311 or teaching experience.

567. Issues and Trends in Early Childhood Education (3) Research, experimental programs and emerging trends in early childhood education; relationships between educational experiences and later intellectual and emotional development. Prerequisites: Ed.Psy. 400 and El.Ed. 467.

585. Workshop in Current Elementary School Problems (1-6) For experienced elementary school teachers: administrative, supervisory, and instructional problems involved in an emerging educational program. Prerequisite: 12 credits of graduate work in education.

588. Problems, Projects, and Area Studies in Elementary Education (1-6) Independent work in the study of topics in elementary education or the develop-

ment of new curriculums, materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of the development head.

594. Seminar in Elementary Education (1-9) Conferences and discussions designed to meet the needs for special study of particular fields in education. Prerequisite: 12 credits of graduate work in elementary education.

ENGINEERING ACOUSTICS (E ACS)

John C. Johnston
Acting Chairman of the Committee on Engineering Acoustics
Ordnance Research Laboratory, Applied Science Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty, Senior Members: Professors Johnson, Pigott, Rowlands, Sevik, Skudrzyk, and Snowdon; Associate Professors Baker and Tichy.

Graduate Faculty, Associate Members: Associate Professors Farwell and Hayek, Senior Research Associate Miller, Assistant Professor Macaluso, Mr. Sibul.

The aim of this program is to enable the student interested in acoustics to obtain an integrated program of courses covering the fundamentals of acoustical science and the biological, communications, and engineering applications of acoustics.

Programs are arranged through a selection of appropriate courses offered by the several departments of science, engineering, and arts, as well as those specifically in the area of engineering acoustics.

Areas of concentration include acoustic signal processing, architectural acoustics, noise and vibration, physical acoustics, speech and hearing, and underwater acoustics. Thesis research in the various areas may be conducted in relevant departments and in the Ordnance Research Laboratory.

The language and communications requirement for the Ph.D. degree may be satisfied by competence in the use of computer language as well as a reading knowledge of a foreign language.

Entering students should hold a bachelor's degree in physics, biology, engineering, architecture, mathematics, or speech and hearing, or in a closely related field; and they should have had at least one year of physics and mathematics including integral calculus. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

ENGINEERING ACOUSTICS (E ACS)

500. Special Problems in Acoustics (1-6) Provides training in selected areas of acoustics by means of supervised investigations or studies. Prerequisite: Phys. 443.

501. Engineering Acoustics Seminar (1 per term) Recent developments and current research in engineering acoustics.

511. Underwater Sound Propagation (3) Theoretical and empirical treatment of sound propagation in the ocean, including effects of the environment, characteristics of targets, and transducers.

512. Sonar Engineering (4) Theoretical and empirical treatment of problems related to the use of underwater sound in target detection and ranging.

513. Modern Acoustic Signal Processing (4) Probability review, representation of signals, noise processes, optimum filtering, ambiguity functions, linear and nonlinear signal processing, application to sonar systems.

514. Electroacoustic Transducers (4) The theory, design, and calibration of passive, linear, reciprocal electroacoustic transducers for use in both air and water media. Prerequisite: Phys. 443.

515. Acoustics in Fluid Media (3) Wave propagation in stationary and moving fluids; acoustic radiation and scattering; standing waves in ducts and cavities. Prerequisites: E.Mch. 524A, Phys. 443.

ENGINEERING MECHANICS (E MCH)

Robert M. Haythornthwaite, *Head of the Department*
227 Hammond Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty, Senior Members: Professors Davids, Hardenbergh, Haythornthwaite, Hu, Jaunzemis, Neubert, and Vierck; Associate Professor Sharma.

Graduate Faculty, Associate Members: Associate Professors Hayek, Kiusalaas, and Zamrik.

Graduate study is available in the following areas: (1) dynamics, including mechanics of rigid bodies, vibration, and stress waves; (2) mechanics of deformable bodies including elasticity, plasticity, viscoelasticity, and continuum mechanics; (3) mechanics of materials and structures including mechanical properties, plates and shells, and plastic analysis; (4) experimental mechanics including experimental stress analysis, photoelasticity, and experimental vibration.

The language and communications requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

The entering student must hold a bachelor's degree in engineering or science and have satisfactorily completed undergraduate courses in mechanics. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

ENGINEERING MECHANICS (E MCH)

400.	Advanced Strength of Materials (3)	*Mr. Kiusalaas*
401.	Elements of Vibrations (3)	*Mr. Vierck*
402.	Applied and Experimental Stress Analysis (3)	*Mr. Conway*
403.	Mechanics of the Solid State (4)	*Mr. Queeney*
404.	Research in Engineering Mechanics (1-6)	*Staff*
407.	Elements of Computer Methods in Engineering (3)	*Mr. Sharma*
408.	Elasticity and Engineering Applications (3)	*Mr. Kiusalaas*
409.	Advanced Mechanics (3)	*Mr. Hardenbergh*
410.	Mechanics of Space Flight (3)	*Mr. Hardenbergh*
412.	Experimental Methods in Vibrations (3)	*Mr. Neubert*
413.	Plastic Analysis of Structures (3)	*Mr. Hu*
414.	Elements of Material Science (3)	*Mr. Kimmel*
421.	Continuum Mechanics (3)	*Mr. Pytel*

422. Continuum Mechanics (3) *Mr. Jaunzemis*
446. Mechanics of Viscoelastic Materials (3) *Mr. Sharma*

500. Advanced Mechanics of Materials (3-6) Strain energy methods; special problems in bending and torsion; curved bars, beams on elastic foundations; thick-walled cylinders, shrink-fit assemblies, and rotating disc; thin-walled pressure vessels; bending of thin plates; buckling of bars and plates. Prerequisite: E.Mch. 13. *Messrs. Kiusalaas and Zamrik*

506. Experimental Stress Analysis (3) Experimental methods of stress determination including photoelasticity, stress coat and electric strain gauge techniques; stress analogies; strain rosettes for combined stress determinations. Prerequisite: E.Mch. 408 or 507. *Mr. Conway*

507. Theory of Elasticity and Applications (3) Equations of equilibrium and compatibility; stresses and strains in beams, curved members, rotating discs, thick cylinders, torsion and structural members. Prerequisite: E.Mch. 13. *Mr. Sharma*

508. Theory of Elastic Stability and Applications (3) Buckling of slender and short members; buckling of I-beams; stability of thin-walled constructions; thin-walled cylinders subjected to external pressures; applications to structural parts including aircraft members. Prerequisites: E.Mch. 12, 13. *Mr. Kiusalaas*

509. Theory of Plates and Shells (3) Bending and buckling of plates; elastic foundations; deformation of shells, multilayer shells, stress and stability analysis, weight optimization, application problems. Prerequisite: E.Mch. 13. *Mr. Kiusalaas*

514. Engineering Mechanics Seminar (1 per term) Current literature and special problems in engineering mechanics. *Staff*

516. Mathematical Theory of Elasticity (3) Fundamental equations and problems of elasticity theory; uniqueness theorems and variational principles; methods of stress functions and displacement potential; applications. Prerequisite: E.Mch. 540. *Mr. Jaunzemis*

520. Advanced Dynamics (3) Dynamics of a particle and of rigid bodies: Newtonian equations in moving coordinate systems; Lagrange's and Hamilton's equations of motion; special problems in vibrations and dynamics. Prerequisites: E.Mch. 12, Math. 72 or 431. *Mr. Jaunzemis*

521. Stress Waves in Solids (3) Theoretical fundamentals, classic experiments; recent advances, including scabbing applications, plastic waves, penetration mechanics, impact, and numerical methods. Prerequisites: E.Mch. 12; Math. 405 or E.Mch. 524. *Mr. Davids*

522. Theory of Vibrations (3) Mathematical theory of vibrating systems; damping phenomena; forced vibrations; analogy between mechanical and electrical vibrations; transverse and torsional oscillation of shafts; vibration of strings, beams, membranes, and plates. Prerequisites: E.Mch. 13, Math. 72 or 431. *Messrs. Vierck and Neubert*

523 Computer Methods in Engineering Analysis (3) Finite elements, finite differences, and matrix methods applied to dynamics, elasticity, wave propagation, heat conduction, structural analysis, and fluid flow. Prerequisites: Cmp.Sc. 401, Math. 72. *Mr. Davids*

524. Mathematical Methods in Engineering (3 per unit) Prerequisite: A.M. 451 or E.E. 435 or M.E. 452. *Messrs. Davids and Hayek*

Unit A (3) Basic tools, including Fourier, Legendre, and other orthogonal series,

special functions, Laplace transforms. Applications in mechanics and other fields. Prerequisite: Math. 73.
Unit B (3) Solution techniques for boundary-value problems in curvilinear coordinates, integral transforms, Green's functions, potentials, applications to diffusion, vibration, wave-propagation. Prerequisite: E.Mch. 524A or Math. 431.

525. Vibration and Shock in Damped Mechanical Systems (3) Rubberlike materials; vibration isolation; structural impedance; wave propagation; multi-force excitation of beams; Timoshenko beams; transients; shock spectra; damage; nonlinear response. Prerequisite: E.Mch. 401 or 522. *Mr. Snowden*

526. Nonlinear Mechanics (3) Integral curves, singular points, self-sustained oscillations, stability problems, Hill's and Van der Pol's equation, mechanical and electrical application. Prerequisite: E.Mch. 522. *Mr. Neubert*

527. Structural Dynamics (3) Dynamic behavior of structural systems; normal modes; input spectra; finite element representation of frameworks, plates, and shells; impedance; elastic-plastic response. Prerequisites: E.Mch. 12, 13.
Mr. Neubert

528. Experimental Methods in Vibrations (3) Investigation of one or more degrees of freedom, free and forced mechanical vibrations, vibration properties of materials, nondestructive testing. Prerequisite: E.Mch. 401 or 522. *Mr. Neubert*

530. Solid State Mechanics (3) Relation between solid state physics and mechanics; mechanical properties for static, fatigue, creep, and impact conditions; high temperature properties; applications. Prerequisite: E.Mch. 14.
Messrs. Hu and Zamrik

531. Theory of Plasticity and Applications (3) Yield condition; plastic stress-strain relations; theory of slip-line fields; applications to bending, torsion, axially symmetric bodies, metal processing. Prerequisite: E.Mch. 507. *Mr. Hu*

533. Determination of Mechanical Properties (3) Experimental methods for determining hardness, elastic constants, creep behavior, fatigue strength, plastic flow, and dynamic properties of metals. Prerequisite: E.Mch. 14 or 530. *Mr. Hu*

534. Photoelasticity (3) Analysis of polariscopes; isoclinics, isochromatics, and stress trajectories; two- and three-dimensional photoelastic methods; determination of principal stresses; model preparation. Prerequisite: E.Mch. 408 or 507.
Mr. Conway

540. Introduction to Continuum Mechanics (3) Algebra and analysis of tensors; balance equations of classical physics; the linear theories of continuum mechanics. Prerequisite: E.Mch. 421. *Mr. Hayek*

541. Nonlinear Theories of Continuum Mechanics (3) The general theory of constitutive equations; finite deformations and elasticity; flow and fluidity; viscoelasticity, modern topics. Prerequisite: E.Mch. 540. *Mr. Hayek*

546. Theory of Viscoelasticity and Applications (3) Linear and nonlinear viscoelastic theories; generalized isotropic and anisotropic viscoelastic stress-strain relations. Prerequisite: E.Mch. 507. *Mr. Sharma*

550. Studies in Engineering Mechanics (1-6) Studies in any field of engineering mechanics.

570. Random Vibrations in Structural Mechanics (3) Probability theory applied to random vibrations of linear and nonlinear systems; excitation by ground motion, turbulence, and noise; acoustic damping. Prerequisite: Aersp. 411 or E.Mch. 401 or 522. *Mr. Neubert*

ENGINEERING SCIENCE (E SC)

JOHN B. NESBITT
Chairman of the Engineering Graduate Committee for Off-Campus Programs
116 Sackett Building

Degree Conferred: M.Eng.

A program leading to the degree of Master of Engineering with a major in engineering science is offered at the Behrend and King of Prussia Graduate Centers and at the Capitol Campus near Harrisburg. Details of the program may be obtained by writing directly to these locations. Addresses are given on page 2 of this bulletin.

The program is designed to provide a broad, advanced education in the engineering sciences with some specialization permitted in the area of a student's major interest. It is offered specifically to permit practicing engineers to pursue advanced studies through evening classes while in full-time employment in industry in the area. Courses offered for the program are all established and controlled by the resident departments at the University Park Campus.

The credit requirements in this major will be satisfied by an appropriate combination of core courses and elective courses. The core courses include offerings in mathematics and in several branches of engineering which have been selected because of their general character and breadth of applicability to all fields of engineering.

A minimum of 33 credits is required of which at least 12 must be at the 500 level. A scholarly written report is also required. Three of the above credits may be applied to this report.

Students may be admitted to the program from a wide variety of disciplines. Students applying for admission are expected to have completed the following core of previous student experience: (1) physics through atomic physics, (2) mathematics through differential equations, (3) one course in engineering thermodynamics, (4) one course in electrical circuits, and (5) basic courses in engineering statics and dynamics. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Further details regarding admission requirements are available from the Directors of the Graduate Centers offering the program.

ENGLISH (ENGL)

HENRY W. SAMS, *Head of the Department*
117 Burrowes Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty, Senior Members: Professors Bayard, Condee, Cramer, Frank, Goldberg, Hansen, Jewkes, Lewis, Meserole, Price, Rubin, Sams, Weintraub, West, and Young; Associate Professors Austin, Bressler, Reed, and Rosenberg.

Graduate Faculty, Associate Members: Associate Professors Borklund, Fitzgerald, Gidez, Rogers, and Walden; Assistant Professor Begnal.

A student may specialize in English literature, American literature, philology, or rhetoric. It is preferred that an entering student present 24 credits in English, but 18 credits in English exclusive of survey and freshman courses will be accepted. If

the student does not present 18 credits in English, he must make up the deficiency early in his graduate work. A thesis is required of all M.A. candidates in this major.

The language and communications requirement for the Ph.D. degree may be met by successful performance in any one of the following options: (1) critical and scholarly competence in one area of the literature of a foreign language; (2) reading, writing, and speaking knowledge of one foreign language; (3) reading knowledge of two foreign languages; or (4) reading knowledge of one foreign language and demonstrated competence (normally by successful course work) in a technique such as computer science, statistics, etc., where relevant to the student's research interest.

Students with a 3.20 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.20 grade-point average may be made for students with special backgrounds, abilities, and interests.

ENGLISH (ENGL)

406. History of the English Language (3) *Messrs. Buckalew and Shedd*
407. History of the English Language for Teachers (3) *Messrs. Buckalew and Shedd*
408. Advanced College Grammar (3)
411. Problems of Style (3)
412. The Writing of Fiction (3-6) *Messrs. Klass, Rogers, Rubinstein, and West*
413. Verse Writing (3-6) *Mr. Haag*
414. Biographical Writing (3) *Mr. Weintraub*
415. Nonfiction Writing (3) *Mr. Klass*
418. Advanced Technical Writing and Editing (3-6) *Messrs. Damerst and Houp*
422. Masters of British Literature (3-6)
423. History of British Literature (3) *Mr. Arnold*
424. Movements in British Literature (3)
432. Masters of American Literature (3-6) *Staff*
433. History of American Literature (3) *Mr. Gidez*
434. Movements in American Literature (3-6) *Staff*
435. The American Short Story (3) *Mr. Bressler*
437. American Poetry (3) *Messrs. Rubin and Hansen*
438. American Drama (3) *Mr. Grecco*
441. Poetry and Prose of the Early Seventeenth Century (3) *Mr. Arnold*
442. Poetry and Prose of the Late Seventeenth Century (3)
443. Jacobean and Caroline Drama (3) *Messrs. Arnold and Jewkes*
444. Shakespeare: the Genres (3) *Messrs. Arnold, Jewkes, Moore, Price, and Reed*
445. Chaucer (3) *Messrs. Frank and Shedd*
446. Milton (3) *Messrs. Christopher, Moore, Condee, and McAdams*
447. The Elizabethan Renaissance (3) *Mr. Reed*
448. English Drama Before Shakespeare (3) *Mr. Jewkes*
449. Studies in Shakespeare (3) *Messrs. Arnold, Jewkes, Moore, Price, and Reed*
450. Readings in English (1-6)
451. Poetry and Prose of the Early Eighteenth Century (3) *Mr. Fitzgerald*
452. Poetry and Prose of the Late Eighteenth Century (3) *Mr. Buck*
455. The Novel in England to Jane Austen (3) *Mr. Fitzgerald*
458. The Drama from Dryden to Sheridan (3) *Mr. Rogers*
461. British Nonfictional Prose of the Nineteenth Century (3) *Miss Austin*
462. Wordsworth and Coleridge (3) *Mr. Cramer*
463. Byron, Shelley, and Keats (3) *Miss Austin*
465. Victorian Novel (3) *Miss Austin and Mr. Lougy*
466. The American Novel to 1900 (3) *Messrs. Gidez and Hansen*

467. Victorian Poetry (3) *Messrs. Cramer and Lougy*
470. Literature of the British Commonwealth (3)
475. Modern British Fiction (3) *Messrs. Maxwell and West*
476. The American Novel Since 1900 (3) *Mr. Young*
477. British and American Poetry of the Twentieth Century (3) *Mrs. Rodgers and Mr. Haag*
478. British and Irish Drama Since 1890 (3) *Mr. Weintraub*
481. History of English Literary Criticism (3) *Messrs. Borklund and Gidez*
488. (C.Lit. 488) Modern Continental Drama (3) *Messrs. Christopher and Grecco*
490. Rhetorical Theory and Practice (3) *Messrs. Holahan and Rubinstein*
491. Literature for Teachers in Secondary Schools (3)
*498. English Institute (6-12)

501. Materials and Methods of Research (4) Materials and techniques of research in English and American literary history; form and content of theses. Required of all graduate students with an English major. *Mr. Meserole*

521. Old English Language (3) An introduction to the main features of the Old English language; readings in simple Old English prose and poetry. *Mr. Buckalew*

522. Beowulf (3) Reading and critical analysis. Prerequisite: Engl. 521.

523. Wordsworth and Coleridge (3) Major and some minor works; the pertinent criticism and scholarship; aspects of the period. *Mr. Cramer*

524. Byron and Shelley (3) Major and some minor works; the pertinent criticism and scholarship; aspects of the period. *Miss Austin*

525. Blake and Keats (3) Major and some minor works; the pertinent criticism and scholarship; aspects of the period. *Miss Austin*

526. Tennyson and Browning (3) *Mr. Cramer*

536. Henry James (3) The development of James as critic, novelist, and short story writer. *Mr. Borklund*

537. Robinson and Frost (3) The art and thought of two American poets who link the traditions of the nineteenth and twentieth centuries.

540. Studies in Elizabethan Prose and Poetry (3-6) *Messrs. Price and Reed*

541. Medieval Studies (3-6) Special problems in medieval English literature. *Messrs. Frank and Rosenberg*

542. Middle English Literature (3) Introduction to Middle English and its dialects; study of the literature of the period exclusive of Chaucer.

543. Studies in Early Seventeenth Century Literature (3-6) Major poets and prose writers from 1600 to 1660. *Mr. Condee*

544. Restoration Literature (3) Selected studies of writers in England between 1650 and 1700. *Mr. Fitzgerald*

545. Chaucer (3-6) Critical study of the *Canterbury Tales* or *Troilus and Criseyde* and minor poems. *Messrs. Frank and Rosenberg*

546. Milton (3) The poetry and prose of John Milton. *Mr. Condee*

* A maximum of 6 credits in one summer.

548. Elizabethan and Jacobean Drama (3-6) English drama from 1558 to 1642 exclusive of Shakespeare. *Mr. Jewkes*

549. Shakespeare (3-6) Special problems of sources, chronology, text, characterization, and motivation in the drama. *Messrs. Jewkes, Price, and Reed*

552. Swift and Pope (3) *Mr. Sams*

553. The Age of Johnson (3) The work of Johnson and his circle. *Mr. Fitzgerald*

554. Studies in Early American Literature (3) *Messrs. Meserole and Hansen*

555. The Puritans (3) Critical studies of the principal works of English and American Puritans. *Messrs. Meserole and Hansen*

556. Eighteenth Century British Fiction (3) *Messrs. Fitzgerald and Sams*

557. Early Eighteenth Century British Literature (3) Prose and poetry in the reign of Queen Anne, with special attention to periodical publications. *Mr. Sams*

560. American Romanticism (3) The Romantic movement in American literature of the mid-nineteenth century. *Mr. Hansen*

561. Studies in the Romantic Movement (3-6) *Miss Austin*

562. Studies in the Literature of Victorian England (3-6) *Miss Austin, Messrs. Cramer and Weintraub*

564. Studies in Nineteenth Century American Literature (3) The major figures treated will vary from year to year. *Messrs. Rubin, Hansen, and Gidez*

573. Studies in Twentieth Century British Literature (3-6) Major writers and literary movements. *Messrs. Weintraub and West*

574. Studies in Twentieth Century American Literature (3-6) Major writers and literary movements.

575. James Joyce (3-6) Alternate terms: *Ulysses* and *Finnegans Wake.* Knowledge of *Dubliners* and *A Portrait of the Artist* is assumed. *Mr. Begnal*

576. Hemingway and Faulkner (3) The major works. *Mr. Young*

578. Shaw (3) The plays, prose writings, and literary influence of G.B.S. *Mr. Weintraub*

579. T. S. Eliot (3) Major works in poetry, criticism, and drama; pertinent scholarship and criticism. *Mr. Lewis*

581. Contemporary Literary Criticism (3) *Messrs. Sams and Borklund*

582. Hawthorne and Melville (3) Detailed study of the major works of both authors and of the relationship between the two men. *Messrs. Young and Gidez*

583. Emerson and Thoreau (3) The significant prose and poetry of the chief American transcendentalists. *Mr. Bressler*

584. Whitman and Dickinson (3) The major texts, with special emphasis on background and language. *Mr. Rubin*

585. Twain and Howells (3) The principal works, the relationship between the two men, and their place in American literature. *Mr. Lewis*

587. Franklin and Edwards (3) Studies in the lives, works, and milieu. *Mr. Meserole*

590. Research Problems in British Literature (3-6) Methods of research, problems of bibliography, and evaluation of sources and materials.

591. Research Problems in American Literature (3-6) Methods of research, problems of bibliography, and evaluation of sources and materials.

592. Studies in American Literary Myth (3) An introduction to an interpretive, interdisciplinary study of some representative themes in American literature and culture. *Mr. Young*

593. (C.Lit. 593) Anglo-American Folk Song (3) Survey of relevant literary and ethnological scholarship and field work, European and American, from the early sixteenth century to the present. *Mr. Bayard*

594. Readings in English (1-6) Programs of readings in English and American literature, designed to meet specific needs of individual students.

595. Studies in British Fiction (3-6) *Mr. Weintraub*

596. Studies in American Fiction (3-6) *Mr. Gidez*

597. Studies in American Poetry (3-6) *Messrs. Rubin and Hansen*

ENTOMOLOGY (ENT)

Beckford F. Coon, *Head of the Department*
102 Patterson Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty, Senior Members: Professors Asquith, Coon, and Rutschky; Associate Professors Benton, Mumma, Smyth, Snetsinger, and Yendol; Assistant Professor Kim.

Graduate Faculty, Associate Members: Associate Professor Ercegovich, Assistant Professors Hower and Smilowitz.

A student majoring in entomology may specialize in various areas of economic entomology and in forest entomology, apiculture, insect resistance in plants, arachnology, medical or veterinary entomology, biological control, insect pathology, insect transmission of plant pathogens, ecology, morphology, embryology, taxonomy, physiology, insect behavior, or chemistry of pesticides.

The language and communications requirement for the Ph.D. degree may be satisfied by a foreign language approved by the student's committee.

For admission a student is required to have 24 credits in entomology and related biological and physical sciences. Chemistry through organic, physics, mathematics, and statistics are advantageous. A limited deficiency may be made up, without degree credit, while pursuing graduate work.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

ENTOMOLOGY (ENT)

401. Medical and Veterinary Entomology (3) *Mr. Kim*
403. (Biol. 403) Systematics (3) *Mr. Kim*

409. Insect Biology and Management (3) *Mr. Rutschky*
412. Field Entomology (3) *Mr. Rutschky*
414. Insect Morphology and Phylogeny (3) *Messrs. Rutschky and Kim*
415. Insect Physiology and Biochemistry (3) *Messrs. Smyth and Mumma*
416. Insect Ecology and Control (3) *Messrs. Hower and Cameron*
431. Special Problems (1-6)
435. Arachnology (3) *Mr. Snetsinger*

515. Insect Morphology and Systematics (1-3) Current theories, controversies and advanced techniques in comparative morphology, histology, embryonic and postembryonic development, taxonomy and systematics of insects. Winter term.

516. Insect Physiology and Biochemistry (1-3) Selected topics in insect function and metabolism. Spring term.

517. Insect Ecology and Behavior (1-3) Selected aspects of the biotic and abiotic interactions of insects. Fall term.

518. Pest Management (1-3) Current concepts and controversies in modern agricultural and urban pest management practice. Winter term.

520. Special Topics (1-6)

531. Insect Toxicology (2) General principles of toxicology and survey of the actions of substances toxic to insects. Fall term, odd years.

532. Insect Behavior (2) Orientation reflexes, learning, communication, and social behavior; physiological bases, ecological and evolutionary implications. Summer term, odd years.

535. Biological Control (3) Practical and theoretical aspects of arthropod control by entomophagous insects and the place of biocontrol in integrated control programs. Spring term, even years. *Messrs. Yendol and Smilowitz*

536. Insect Pathology (3) Diseases of arthropods and some aspects of microbial control of insects. Prerequisite: Micrb. 1. Spring term, odd years.

596. Seminar (1)

ENVIRONMENTAL POLLUTION CONTROL (EPC)

William J. Moroz
In Charge of Graduate Programs in Environmental Pollution Control
226 Chemical Engineering Building Unit 2

Degrees Conferred: M.S., M.Eng., M.E.P.C

This program deals with the various aspects of the control of air and water pollution and the disposal of solid wastes. It is open to graduate students interested in pursuing work in any of these areas. Graduate instruction is under the direction of an interdisciplinary executive committee and the departments participating in the program. The faculty consists of graduate faculty members of the Graduate School with a teaching and/or research interest in the area of environmental pollution control.

A student must satisfy the general requirements of the Graduate School and the following program requirements: (1) He must pass 9 credits of core courses: C.E. 472, Water Pollution Control; C.E. 476, Solid Waste Management; and M.E. 470, Intro-

duction to Air Pollution Control. In addition he must select at least 24 of his total credits from a recommended course list and schedule an environmental pollution control seminar (500) for three terms. The selection of an option to prepare a thesis must be in the area of environmental pollution control.

The Master of Environmental Pollution Control is an interdisciplinary professional degree designed for students who are interested in pursuing a career in the control of air and water pollution and pollution from the disposal of solid wastes. A minimum of 30 graduate credits are required of which at least 9 must be at the 500 level and 20 must be taken at the University Park Campus. A thesis is optional. If a thesis is written, at least 6 credits of thesis research (600 or 610) must be taken.

Admission to the program will be granted jointly by the Graduate School, the department in which the student plans to follow his studies, and the Environmental Pollution Control Executive Committee. All program degrees will be granted by the participating departments. All thesis credits will be taken in the department in which the student is enrolled. For the M.S. degree a thesis will be optional. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

EXTENSION EDUCATION (EXTED)

W. M. Smith, Jr.
Chairman of the Committee on Extension Education
105 Weaver Building

Degrees Conferred: M.Agr., M.Ed.

This program is designed primarily to meet the needs of professional teachers in various extension and adult education positions. The purpose is to train individuals to develop attitudes, understandings, and competences which enable them to become more effective professional workers. Options have been developed for the Colleges of Agriculture and Human Development. Additional options will be offered as they are developed by other colleges.

For either degree a minimum of 30 credits is required, in addition to a professional paper. These credits should be distributed as follows: 12 credits in extension core courses, 6 in communication and/or education, and 12 in two areas of agriculture and/or home economics.

Admission requirements include a strong background in agriculture or home economics and a minimum of 12 credits in the social sciences. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

FAMILY ECONOMICS AND HOME MANAGEMENT (FE HM)

(See Human Development and Family Studies)

FOOD SCIENCE (FD SC)

Donald V. Josephson
Chairman of the Division of Food Science and Industry
111 Borland Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Josephson, Keeney, McCarthy, Patton, Watrous, and Adjunct Professor Day; Associate Professors Dimick, MacNeil, McArdle, Sink, and Adjunct Associate Professor Thompson.

Graduate Faculty, Associate Members: Associate Professors Kuhn and Ziegler, Assistant Professor Kroger.

Opportunities are available for study in the fields of dairy products, meats, fruits and vegetables, and poultry products. Special emphasis can be devoted to food chemistry, microbiology, quality control, flavor control and acceptance, rheology, processing, packaging, and distribution.

The language and communications requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Prerequisite to graduate work is the completion of an undergraduate degree in food technology, biochemistry, microbiology, or other related area. The undergraduate program must have included college mathematics and physics. Students may be admitted with limited deficiency but are required to make up undergraduate deficiencies without degree credit. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

FOOD SCIENCE (FD SC)

400. Effects of Processing on Foods (3)
402. The Thermal Process (1)
403. Sanitation and Quality Control (3)
410. Chemical Methods of Food Analysis (4)
421. Technical Control Problems (1-6)

505. Concepts of Product Development (3) Interrelationships of processing principles and chemical and physical properties in the development of new and improved food products.

507. Food Quality, Food Standards, and Consumer Protection (2) Problems of the food industry relating to contamination and quality of food products.

510. Seminar in Food Science (1-6)

520. Problems in Food Science (1-9) Special problems in dairy, horticultural, meat, poultry, and other food products.

522. Research Procedures in Food Science (3) Research problems and methods in food science with major emphasis on food chemistry.

In addition to the courses listed above, the following courses are available in food science; their descriptions may be found under the offerings of the cooperating departments: A.I. 421, 431, 502; Ag.E. 412, 413, 414, 423, 503; D.Sc. 427, 521; Hort. 528; Micrb. 414; Pty.Sc. 504.

FOODS AND NUTRITION (F N)

Helen A. Guthrie
In Charge of Graduate Programs in Foods and Nutrition
206 Human Development Building

Degrees Conferred: Ph.D., D.Ed., M.S., and M.Ed. in Foods and Nutrition; M.S. in Nutrition in Public Health.

Graduate Faculty, Senior Members: Professor Pike, Associate Professors Cox and Guthrie.

Graduate Faculty, Associate Member: Assistant Professor Brinkman.

Graduate programs in foods and nutrition prepare students for careers in college teaching, research, and adult program leadership. The program in nutrition in public health prepares the student for work in public health agencies.

The language and communications requirement for the Ph.D. degree may be satisfied by competence in technical writing and informative speaking.

For admission to a graduate program in foods and nutrition, a student must have completed at least 9 credits in organic and inorganic chemistry, 3 in biochemistry, 3 in microbiology, 3 in physiology, 4 in other physical and biological sciences, and 8 in foods and nutrition.

For admission to the program in nutrition in public health, the requirements are at least 9 credits in organic and inorganic chemistry, 3 in biochemistry, 3 in microbiology, 12 in social sciences, 7 in foods, and 4 in nutrition. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

NUTRITION (NUTR)

400. Special Problems in Foods and Nutrition (1-3)
420. Experimental Cookery (3)
421. Cultural and Aesthetic Aspects of Food (3)
422. Scientific Principles of Food Preparation (3)
452. Nutritional Aspects of Disease (3)
453. Diet Therapy (2)
456. Nutrition in the Community (3)
457. Principles of Nutrition (3)
458. Applied Nutrition (2)
459. Advanced Nutrition (3)
490. Foods and Nutrition Seminar (1)

520. Readings in Applied Nutrition (2) Critical review and reports of literature on selected topics in applied nutrition.

521. Topics in Nutrition (1-6) Intensive study of current developments on selected topics in nutrition.

522. Advanced Experimental Foods (3) Experimental methods used in measuring the quality of foods; specific problems in food preparation.

530. Problems in Foods and Nutrition (1-6)

550. Readings in Nutrition (3) Readings and reports of selected topics in nutrition.

551. Seminar in Nutrition (1-6) Selected topics and recent advances in nutrition.

552. Nutrition in Disease (3) Physiological and biochemical problems in metabolic diseases and the nutritional aspects of therapy.

555. Field Work in Nutrition (2-4) Field problems planned to meet the needs of individual students. Hours and problems to be arranged.

556. The Survey Method in Foods and Nutrition (2) Study of survey techniques as a tool in the assay of food adequacy and nutritional status.

557. Interrelationships of Nutrients (2) Interrelationships of nutrients in the metabolic processes; their significance as applied to nutrition.

FOREST RESOURCES (FOR R)

Wilber W. Ward
Director of the School of Forest Resources
101 Forestry Building

Degrees Conferred: Ph.D., M.S., M.F.

Graduate Faculty, Senior Members: Professors Fletcher, Gerhold, Hutnik, Sopper, and Ward; Associate Professors Borden, George, Murphey, and Shipman.

Graduate Faculty, Associate Members: Adjunct Associate Professor Lindzey; Assistant Professors Beall, DeWalle, Dress, and Turner.

The graduate programs include two areas of technological inquiry, forest resource management and forest products; and two areas of scientific inquiry, forest science and wood science.

The language and communications requirement for the Ph.D. degree may be satisfied by a demonstrated competence in one foreign language equivalent to passing three college-level courses.

The technological area of forest resource management, which is concerned with planning and operation of the forest land complex, may include specialization in timber management, wildlife management, watershed management, forest recreation, or a combination of all of these land use concepts within the framework of multiple objectives. An undergraduate degree in forest management or a similar program emphasizing biological science, economics, and mathematics provides the preparation necessary for these specializations.

The technological area of forest products is concerned with the application of wood technology to the forest products industries with possible specialization in industrial management, quality control, and marketing. An undergraduate degree in wood utilization or a similar program emphasizing mathematics and basic engineering courses is prerequisite.

The forest science area is concerned with those disciplines fundamental to forest management, including forest ecology, wildlife ecology, forest economics, forest entomology, forest genetics, forest hydrology, forest pathology, forest soils, tree physiology, mensuration, and silviculture. An undergraduate degree in forestry or a comparable degree emphasizing mathematics and biological, chemical, and physical sciences is prerequisite.

The wood science area is concerned with the fundamentals of the structural, physical, mechanical, and chemical properties of wood. The student may specialize in wood anatomy, wood moisture relations, wood chemistry, wood adhesion, wood engi-

neering, and pathological and entomological considerations of wood products. An undergraduate degree in wood utilization or its equivalent in mathematics and biological and physical sciences is prerequisite.

For admission a student should present at least a 2.50 all-university average and 9 credits of basic biology; 12 credits of calculus, statistics, or computer science; 12 credits of chemistry and physics; 12 credits of communications; 12 credits of economics and social sciences, or humanities; and 18 credits in the professional fields served by the School of Forest Resources. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. All applicants should submit a brief statement describing their interests, goals, and special qualifications related to their proposed graduate studies.

FORESTRY (FOR)

403. Dendrology (3)
410. Forest Resources Seminar (1)
416. Forest Recreation (3)
421. Silviculture (3)
427. Forest Range Management (3)
440. Forest Economics and Finance (3)
450. Advanced Mensuration (3)
455. Aerial Photos in Forestry (3)
466. Forest Resource Management (3)
480. Policy and Administration (3)
497. Problems in Forestry (1-6 per term)

508. Advanced Forest Ecology (3) Organization, development, and classification of forest communities. Prerequisite: For. 308.

509. Wildlife Habitat Management (3) Management of forest associations for maintenance and development of wildlife. Prerequisite: For. 508 or Biol. 516.

512. Forest Genetics (3) Theoretical and practical application of genetics to forestry; experiments in genetic variation, breeding, progeny testing, and vegetative propagation of trees. Prerequisite: Biol. 22.

517. Forest Microclimatology (3) Forest microclimatology quantitative treatment of climate near the ground, with special reference to the role of forests and terrain. Prerequisite: Phys. 202.

519. Forest Hydrology (3) Influence of forest cover on the disposition of precipitation and the application of hydrologic principles and techniques to forest watersheds. Prerequisites: For. 308, C.E. 51.

521. Advanced Silviculture (3) Specific silvicultural practices for the establishment and manipulation of forest stands with respect to recent developments and research needs. Prerequisite: For. 421.

525. Forest Land Use Alternatives (3) Recognition and analysis of various compatible and conflicting uses of forest land as a component of rural land. Prerequisites: For. 466, Ag.Ec. 421 or Geog. 405, 3 credits in statistics.

550. Design and Analysis of Experiments (3) Specialized techniques involved in the design and analysis of complex forestry research problems. Prerequisite: For. 450.

560. Timber Management (3) Technical methods in the organization and control of the forest property for timber production.

575. Applications of Forest Economics and Finance (3) Survey of situations in forestry where business problems and particular circumstances of production, value, and costs are currently significant. Prerequisite: For. 440.

590. Seminar Topics (1 per term) Critical and rigorous review of specialized topics presented as seminar reports.

597. Research Topics (1-6 per term) Obtaining and analyzing published or original information on a special topic and presenting it in written form.

WOOD SCIENCE (W S)

411. Physical Properties of Wood (3)
412. Mechanical Properties of Wood (3)
413. Chemical Properties of Wood (3)
414. Pulp and Fiber Technology (3)
420. Processing and Machining of Wood (2)
421. Adhesives and Finishes for Wood Products (2)
422. Seasoning and Preservation (2)
430. Forest Products Manufacturing Systems and Standards (3)
469. Problems in Wood Science (1-6)
491. Logging and Lumbering (3)
495. Forest Products Production Management (3)
497. Small Sawmills (3)

502. Wood Fibers (3) Identification and physical and chemical characteristics of wood fibers used for pulp, either for paper or as a source of cellulose; pulping quality, fiber measurements.

511. Wood-Fluid Relationships (3) Treatment of adsorption equations, thermodynamics, and diffusion through wood. Prerequisite: W.S. 337.

513. Wood Chemistry (3) Treatment of the chemical components of wood, their distribution and reactions. Prerequisite: W.S. 413.

531. Mechanical Behavior of Wood (3) Time-dependent properties, theory of failure, rheologic properties, and theory of the mechanical behavior of wood and structural composites.

532. Theory of Adhesion (3) Theory of adhesion as it pertains to bonding of wood, paper-based laminates, fibers, and bonding of wood to dissimilar materials.

590. Seminar Topics (1) Critical and rigorous review of specialized topics presented as seminar reports.

595. Forest Products Industrial Operations Analysis (3) Applications of operations research methods in the forest products industry; mathematical programming, simulation, waiting line problems, sequencing. Prerequisite: W.S. 495.

597. Research Topics (1-6) Obtaining and analyzing published or original information on a special topic and presenting it in written form.

FRENCH (FR)

RICHARD L. FRAUTSCHI, *Head of the Department*
S-404 Burrowes Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty, Senior Members: Professors Belasco, Brault, Chapman, Frautschi, Hyslop, and LeSage.

Graduate Faculty, Associate Member: Associate Professor Knight.

A student may follow a graduate program in French literature and in descriptive and historical linguistics with a minor in a related field. M.A. candidates may submit either a thesis or a term paper. If the latter is chosen, 6 additional credits in 500-level courses in the major field must be scheduled. The language and communications requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages or by a comprehensive knowledge of one.

The minimum requirement for admission to an advanced degree program will normally be 27 credits of post-intermediate work in language and literature. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

FRENCH (FR)

417. FRENCH PHONOLOGY (3)
418. FRENCH MORPHOLOGY AND SYNTAX (3)
422. OLD FRENCH LITERATURE (3)
426. FRENCH LITERATURE OF THE RENAISSANCE (3)
435-436. SEVENTEENTH CENTURY FRENCH LITERATURE (3 each)
445. THE FRENCH NOVEL OF THE EIGHTEENTH CENTURY (3)
446. FRENCH DRAMA OF THE EIGHTEENTH CENTURY (3)
451-452. NINETEENTH CENTURY FRENCH LITERATURE (3 each)
460. FRENCH PROSE OF THE TWENTIETH CENTURY (3)
461. FRENCH POETRY AND DRAMA OF THE TWENTIETH CENTURY (3)
470. ADVANCED COMPOSITION AND CONVERSATION (3)
480. THE TEACHING OF FRENCH (4)
491. PROBLEMS IN FRENCH LITERATURE (3-6)
499. FOREIGN STUDY IN FRENCH (3)

*1G. ELEMENTARY FRENCH FOR GRADUATE STUDENTS (3) Designed for students preparing to satisfy language requirements for advanced degrees.

*2G. ELEMENTARY FRENCH FOR GRADUATE STUDENTS (3) Continuation of Fr. 1G with reading practice.

500. AN INTRODUCTION TO OLD FRENCH (3) Analysis of the phonology, morphology, and syntax of the Old French language based on early literary monuments.

503. FRENCH PHONOLOGY (3) Articulatory and acoustic correlates of distinctive features; synchronic dialectology; phonology in generative grammar.

* No graduate credit is given for this course.

504. French Morphology and Syntax (3) Principles of segmentation and decomposition; tagmemics and transformation theory; morphophonemics.

505. Semantic Theory of the French Language (3) The goals of semantic description; systematic interrelation of semantic generalizations; empirical and methodological constraints.

516. The Song of Roland (3) Seminar in the Old French *Chanson de Roland,* with emphasis on the problems of textual criticism and literary analysis.

517. Villon (3) The poetry of Villon with reference to the cultural and social context of the late medieval period.

518. Medieval French Drama (3) The development of French drama from its liturgical origins to the flourishing comic theater of the late Middle Ages.

526. Rabelais (3) Seminar in works of François Rabelais, notably Book I (Pantagruel) and Book II (Gargantua), with emphasis on comic devices and narrative technique.

527. French Renaissance Poetry (3-6) Evaluation of French poetry from Marot through the Pléiade; emphasis on Ronsard and DuBellay.

528. Montaigne (3) Genesis and evolution of Montaigne's creation of the personal essay; influence of the *Essais* in seventeenth, eighteenth century French literature.

533. Seventeenth Century Prose and Poetry (3) The development of Classicism; its apogee and decline as seen in the works of major prose writers and poets.

534. Moliere (3) The literary achievement of Molière, the comic playwright, director, actor, and founder of the Comédie Française.

535. Seventeenth Century French Tragedy (3) The development and triumph of tragedy as a literary genre with special emphasis on the achievement of Corneille and Racine.

536. La Fontaine (3) The literary artistry of La Fontaine with special emphasis on his contribution as a fabulist.

540. Voltaire (3) The artistic and philosophical evolution of Voltaire as seen in the tragedy, the philosophical tale, and poetry.

541. Rousseau (3) Rousseau's rationalistic critique of civilization; his sentimental rehabilitation of the individual, family, state; Rousseau precursor of Romanticism.

542. Diderot and the Encyclopedists (3) The literary *philosophe* in the Age of Enlightenment with special emphasis on Diderot and his collaborators on the *Encyclopédie.*

561. French Romanticism (3) The Romantic movement in French literature with emphasis upon its major exponents in prose and poetry.

563. French Realism (3) The Realistic movement in French literature with emphasis upon its major exponents in prose and poetry.

565. The Nineteenth Century French Novel (3) The development of the novel in the nineteenth century with emphasis on Constant, Balzac, Stendhal, Flaubert, and Zola.

567. Twentieth Century French Theatre (3) Evolution of the French theatre form the plays of the *belle époque* to the avant-garde works of today.

568. Baudelaire (3) A study of his poetry and his criticism.

569. Masters of Twentieth Century French Literature (3-6) Major literary figures of contemporary French literature.

571. French Literary Criticism from Sainte-Beuve to Present (3) Evolution of French literary criticism from Sainte-Beuve, the "father" of modern literary criticism, to contemporary critics.

581. Theory and Techniques of Teaching French (1-3)

590. Seminar in French Literature (3-12) Lectures on methods of research. Students will pursue common and individual investigations in fields selected after consultation with the instructor.

595. Analysis of French Civilization (3-6) French cultural aspects, other than language and literature, conducted in French with the collaboration of specialists outside the French department.

596. Symbolism (3) The anti-positivistic tradition in nineteenth century French literature dealing with the Symbolist School; its antecedents and its subsequent ramifications.

597. Research Techniques and Bibliography in French Language and Literature (1-3)

FUEL SCIENCE (F SC)

Howard B. Palmer
In Charge of Graduate Programs in Fuel Science
320 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Austin, Essenhigh, Given, Palmer, and Walker; Associate Professor Vastola; Assistant Professor Polansky.
Graduate Faculty, Associate Member: Assistant Professor Becker.

This program is one of the options in which a graduate student in the Department of Material Sciences can receive an advanced degree.

Research facilities, well instrumented, are available for the study of high temperature gas reactions by shock-tube and other techniques, electrochemical kinetics of fuel cell and battery systems, reactions in plasmas and flames, physics and chemistry of carbons and graphites, fundamental processes in the industrial combustion of gaseous, liquid, and soil fuels, mass spectrometric investigation of the structure of solids, comminution of brittle materials, and the organic geochemistry of plant-derived sediments. Students can plan a wide variety of programs of study, to suit individual needs; coherent interdisciplinary programs are encouraged. The no-thesis option is available for the M.S. degree.

A basic minimum of 30 course credits is required for the Ph.D. degree, of which at least 12 must be in departmental courses. The language and communications requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Applications will be accepted from persons having backgrounds in chemistry or physics; chemical, mechanical, or aerospace engineering; material sciences; or earth sciences. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions

to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

FUEL SCIENCE (F SC)

400. Fuel Science Research and Design (1-10 per term)
410. Fuel Science Laboratory (1) *Mr. Polansky and Staff*
421. Flames (3) *Mr. Becker*
422. Combustion Engineering (3) *Mr. Essenhigh*
423. Combustion Laboratory (1) *Mr. Essenhigh*
424. Energy in Space Travel (3) *Mr. Vastola*
431. The Chemistry of Fuels (3) *Mr. Given*

504. (Gchem. 504) Organic Geochemistry of Coal (3) Interdisciplinary study of accumulation of organic sediments and their metamorphism into coal macerals; effects of environment; structure of coal macerals.

506. Carbon Reactions (3) Current approaches to heterogeneous reactions in combustion and gasification of carbons and graphite. Prerequisite: Chem. 452. *Mr. Walker*

510. Special Topics in Fuel Science (1-6 per term)

511. Fuel Science Seminar (1 per term) Selected topics from current research relevant to fuel science.

512. High Temperature Kinetics and Flame Propagation (3) Laminar and turbulent premixed and diffusion flames; gaseous detonations; rate processes in high temperature gases. Prerequisite: F.Sc. 421. *Mr. Palmer*

514. Jet and Rocket Fuels (2) Propulsion systems; combustion chamber conditions; liquid and solid propellants, slurries, fuel sprays, and finely divided solids. Prerequisite: F.Sc. 421. *Mr. Palmer*

Note: *Courses in the use of X-ray diffraction, electron microscopy, spectroscopy, and electronic instrumentation in fuel science studies are listed under Materials Science.*

GENERAL ENGINEERING (GEN E)

Otis E. Lancaster
Chairman of the Committee on General Engineering
101 Hammond Building

Degrees Conferred: M.Ed., M.Eng.

This program is designed primarily to meet the needs of the engineering faculty in the various technical institutes. The objective is to give academic preparation to those individuals who will teach engineering subjects at the two-year college level.

For either degree a minimum of 30 credits is required in addition to a scholarly written report. Twenty-four of these credits should be in engineering, physics, and mathematics. A candidate is expected to earn at least 3 credits each in mathematics, physics, and two fields of engineering, or demonstrate competence in them.

For the M.Ed. 6 credits must be in education, consisting of one 3-credit course in the theory of learning and teaching and one 3-credit course in internship in college teaching. Fifteen credits must be earned at the 500 level.

For the M.Eng. degree 6 credits may be taken in any field approved by the committee, but at least 12 credits in engineering subjects must be at the 500 level.

For admission an undergraduate degree in engineering, physical science, mathematics, or the equivalent is required. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

GENERAL FAMILY STUDIES (G F S)

(See Human Development and Family Studies)

GENETICS (GENET)

EDWARD G. BUSS, *Chairman of the Committee for Genetics*
203 Animal Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Buss, Dalton, Deering, Gerhold, Ginoza, Goodwin, Grun, O'Mara, R. Nelson, Person, Starling, Vesell, Walker, Wright, and Zimmerman; Associate Professors Cleveland, Creech, Snipes, Wilson, and Adjunct Associate Professor Marshall; Assistant Professor Todd.

Graduate Faculty, Associate Members: Associate Professors Johnson, Pfeifer, Thoele, and Adjunct Associate Professor R. Hill; Assistant Professors Ayers, Costantino, Craig, Lennox, and Risius.

The program for genetics is interdepartmental, and faculty from the Colleges of Agriculture, Medicine, and Science serve as major advisers and on committees for the majors. The student is encouraged to select his major adviser.

Opportunities for graduate study and research are available in biochemical, developmental, molecular, population, cyto- and pharmacogenetics. Organisms available for research include fungi; bacteria; fish; amphibia; birds; man; grain, forage, and horticultural plants; and forest trees. The graduate faculty committees for majors have the responsibility and jurisdiction for determining course work, specific requirements in communications skills exceeding the minimum, and research acceptable for satisfying degree requirements. The language and communications requirement for the Ph.D. degree may be satisfied by an ability to read and translate articles in at least one language in addition to English.

To be considered for admission to the genetics program a student should have 30 or more credits in biology and a combined total of 30 or more credits in chemistry, physics, and mathematics. Students with a grade-point average of 3.00 or better in science and communications courses and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Students with limited deficiencies may be admitted but must make up such deficiencies concurrently with their graduate studies.

The following genetics courses are available: An.Sc. 422, 455; Agro. 411, 509, 510; Biol. 405, 422, 425, 427, 428, 505, 528; B.Chem. 503; Bphys. 430; C.Med. 503; For. 512; Hort. 407, 444; Micrb. 516, 553, 556; Pharm. 515, 540; P.Path. 543. Twelve credits in these courses are required for the M.S. degree in genetics or a minor in genetics for a Ph.D.; 15 credits in these courses and 3 credits in genetics seminar are

required for a Ph.D. major in genetics. Transfer credits for courses in genetics may be accepted as substitutes for the above listed courses.

GEOCHEMISTRY (GCHEM)

ARTHUR L. BOETTCHER
In Charge of Graduate Programs in Geochemistry
211 Deike Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Barnes, Bates, Brindley, Burnham, Greig, Griffiths, Keith, Muan, Newnham, Roy, Thornton, and Wickman; Associate Professors Boettcher, Dachille, Rose, Smith, and White.

Graduate Faculty, Associate Members: Assistant Professors Deines, Langmuir, and Suhr.

Areas of specialization include crystal chemistry, phase equilibria, element distribution and affiliations, isotope geochemistry, geochemical prospecting, cosmochemistry, high-temperature and high-pressure geochemistry, and solid state technology.

The language and communications requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages or by comprehensive knowledge of one.

Before starting graduate study, an applicant is generally expected to have had a standard introductory course in each of the following four subjects—chemistry, physics, geology, and mineralogy; 12 credits of intermediate-level work in any one or a combination of chemistry, physics, and geological science; and mathematics through integral calculus. Students who have taken somewhat less than the indicated minimum of subjects may be admitted but must make up their deficiencies concurrently with their graduate studies.

Students who present a 2.70 grade-point average in their basic science and geoscience subjects and other appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the 2.70 grade-point average may be made for students with special backgrounds, abilities, and interests.

The no-thesis option is available for the M.S. degree.

GEOCHEMISTRY (GCHEM)

402. INTRODUCTION TO ORGANIC GEOCHEMISTRY (3)
457. GEOCHEMICAL EXPLORATION (3) *Mr. Rose*
471. (Geol. 471) FIELD STUDIES IN NORTH AMERICA (3)

501. RESEARCH (1-10 per term) Research in geochemistry.

502. (Geol. 502) CARBONATES IN THE MARINE ENVIRONMENT (3) Ancient carbonate rocks and recent carbonate sediments, with emphasis on modern field and laboratory methods and a multidisciplinary approach.

504. (F.Sc. 504) ORGANIC GEOCHEMISTRY OF COAL (3) Interdisciplinary study of accumulation of organic sediments and their metamorphism into coal macerals; effects of environment; structure of coal macerals.

509. GEOCHEMISTRY SEMINAR (1 per term)

510. PROBLEMS IN GEOCHEMISTRY (1-9) Laboratory and library study of special problems.

512. (Mat.Sc. 512) Principles of Crystal Chemistry (2-4) Relation of structure to ionic size and nature; influence of pressure and temperature on structure; chemical-structural defects, crystalline solutions, phase-transitions. *Mr. Roy*

513. Phase Equilibria in Mineral Systems at High Temperatures (2-4) Interpretation of phase diagrams with emphasis on high-temperature oxide systems at atmospheric pressure; measurement of p-t-x, determination of equilibrium diagrams. *Mr. Muan*

514. Element Distribution in the Earth (3) Principles and data from studies of phase equilibria, petrology, and crystal structure as related to distribution of elements in minerals, rocks, and the earth. *Mr. Wickman*

517. Age Determinations (1-2) Geochemistry of radioactive elements and their daughters; age determination techniques and observations. *Mr. Deines*

518. Stable Isotope Geochemistry (3) Theory of isotope fractionation mechanisms; its application to a wide range of problems in the earth and planetary sciences. *Mr. Deines*

519. Cosmochemistry and Nucleogenesis (2) Distribution and composition of matter; origin of solar system and earth, of constituent nuclides, of life.

520. P-T-X Phase Equilibria (3) Phase equilibrium in mineral systems with pressure as a variable. Prerequisite: Gchem. 513. *Mr. Boettcher*

522. Geochemistry of Aqueous Systems (3) Ionic and molecular equilibria related to stabilities and solubilities of minerals: Eh-pH, Po_2-pH relations applied to ground water, sea water, hydrothermal fluids. *Messrs. Barnes and Schmalz*

523. Water-Resource Geochemistry (2-4) Topics and problems concerning the chemical quality of surface waters and ground waters related to hydrogeologic and cultural controls. *Mr. Langmuir*

524. (Mat.Sc. 524) Vibrational Spectra of Materials and Minerals (2) Infrared and Raman spectroscopy of solid materials with applications to crystal chemistry, materials characterization and glass research. Prerequisites: Phys. 412, 471.

525. Electronic Properties of Minerals (2) Application of spectroscopy to mineralogy. Crystal field, EPR, NMR, Mossbauer spectra. Application to order-disorder, element distribution, mineral stability. Prerequisites: Phys. 412, 471.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in geochemical studies are listed under Materials Science.*

GEOGRAPHY (GEOG)

Wilbur Zelinsky, *Head of the Department*
442 Deike Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors Deasy, Gould, Lewis, Miller, Rodgers, Wernstedt, and Zelinsky; Associate Professor Simkins.

Graduate Faculty, Associate Members: Assistant Professors Abler, Downs, and Williams.

The student may concentrate in subjects that call upon the special skills and interests of the staff. At the present time these include: geographic theory; methods of

geographic analysis; the cultural geography of Anglo-America; population problems and the human use of the environment; microspatial behavior of individual actors in space; macrospatial analysis in regional and urban development; and regional development problems in Africa, Latin America, Southeast Asia, and Southern Europe. All students receive training in cartographic, statistical, and bibliographic techniques.

Students wishing to specialize in the field of population may also qualify for admission to a population issues program. This program is a course of study focusing on the social, economic, and geographical policy-related issues resulting from the dynamics of population trends, especially in developed nations. In addition to departmental admission requirements, the population issues committee evaluates the student's interest and aptitude for the training program, which consists of a minimum of 21 credits of interdisciplinary course work in population.

The student has the option for the M.S. degree to complete a thesis or a paper. The master's program is broadly based, designed to provide a beginning graduate student with basic training in systematic fields as well as in geographic theory and research techniques. This basic training underlies more specialized study at the doctoral level where a candidate selects two fields of concentration. A student may elect to specialize in the geography of a region only if faculty members have research experience in that region. The language and communications requirement for the Ph.D. degree may be satisfied by either a reading competence in a modern foreign language with faculty approval or comparable facility in mathematics, statistics, or computer science.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

GEOGRAPHY (GEOG)

401. Historical Geography of North America (3) *Mr. Lewis or Mr. Zelinsky*
402. Cultural and Anthro-Geography (3) *Mr. Zelinsky*
405. Geography of Population (3) *Mr. Zelinsky or Mr. Simkins*
406. Human Use of Environment (3) *Mr. Knight*
407. Geography of Settlement (3) *Mr. Williams*
410. Cartography—Map Design and Construction (3) *Mr. Deasy*
412. The Geography of the Future (3)
420. Urban Geography (3) *Mr. Downs*
427. Geography of the Soviet Union (3) *Mr. Rodgers*
428. Geography of Eastern Europe (3)
430. Agricultural Geography (3) *Mr. Knight*
433. Regional Climatology (3) *Mr. Wernstedt*
434. Regional Physiography (3) *Mr. Lewis*
440. Geography of Middle America (3) *Mr. Simkins*
441. Geography of South America (3) *Mr. Simkins*
442. Regional Systems in Europe (3) *Mr. Miller*
443. Geography of the Orient (3) *Mr. Wernstedt*
444. Geography of Africa (3) *Mr. Knight*
445. Geography of Southern Asia (3) *Mr. Wernstedt*
450. Development of Geographic Thought (3) *Mr. Abler*
451. Map Interpretation (3) *Mr. Lewis*
452. Interpretation of Aerial Photographs (3) *Mr. Deasy*
454. Spatial Analysis I (3) *Mr. Gould, Mr. Williams, or Mr. Strack*
455. Spatial Analysis II (3)
457. Geographic Data Systems (4) *Mr. Williams*
460. Political Geography (3) *Mr. Lewis*
470. Industrial Location and Development (3) *Mr. Rodgers*

475. Geography of Communications Systems (3) *Mr. Abler*
480. Manufactural Systems Analysis (3) *Mr. Miller*
489. Problems in Geography (3) *Staff*
497. Directed Readings (1-9) *Staff*

500. Introduction to Geographic Research (3)

501. Geographic Bibliography (1) An introduction to the techniques of bibliographic search and the writing of research papers in geography. Prerequisite: Geog. 500.

503. Advanced Regional Geography (3-12) Intensive study at an advanced level of selected regions or sections of the continents. Prerequisite: 12 credits in geography.

504. Physical Geography Seminar (3-12) The examination of current problems and theories in physical geography through critical discussion of the literature and student research.

505. Economic Geography Seminar (3-12) The examination of current problems and theories in economic geography through critical discussion of the literature and original student research.

506. Political Geography Seminar (3-6) The exploration of current problems and theory in political geography through critical discussion of the literature and original student research. Prerequisite: Geog. 460.

508. Cultural Geography Seminar (3-6) The exploration of current problems and theory in cultural geography through critical discussion of the literature and original student research.

509. Population Geography Seminar (3) Selected problems in population geography with emphasis on analysis and presentation of data. Prerequisite: Geog. 405.

510. Physical Geography Research (3-10) Directed study in physical geography focusing on theory, analytical methods, or a selected problem.

511. Economic Geographic Research (3-10) Directed study in economic geography focusing on locational theory, analytical methods, or a selected problem.

512. Cultural and Political Geography Research (3-10) Directed study in cultural or political geography focusing on theory, analytical methods, or a selected problem.

520. Metropolitan Analysis (3) Land use models, urban factorial ecology; intraurban movements; urban renewal, ghetto structure, residential change; commercial structure, blight. Prerequisite: Geog. 420 or 456.

543. Conceptual Frameworks for Geographical Analysis (3) Critical analysis of structures of inquiry in geography: modeling, problems of causation, measurement, and ordering of spatial information.

567. Applied Quantitative Methods (3) Simulation, topological, queuing, programming, factor analytic, discriminant, and game theoretic models applied to geographic problems of spatial diffusion and interaction. Prerequisite: Geog. 456.

GEOLOGY (GEOL)

ROBERT F. SCHMALZ
In Charge of Graduate Programs in Geology
304 Deike Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Ridge, Schmalz, Scholten, Spackman, Traverse, Williams, and Wright; Associate Professors Gold, Parizek, Voight, and Weber.

Graduate Faculty, Associate Members: Associate Professor Guber, Assistant Professor Cuffey.

Programs are offered in stratigraphy, paleontology, sedimentation, paleobotany, palynology, regional and structural geology, geomorphology, ground water geology, engineering geology, marine geology and chemical oceanography, coal geology, coal petrology, and geology of metallic and nonmetallic deposits.

The language and communications requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages or by comprehensive knowledge of one.

For admission 25 credits in chemistry, physics, mathematics, and biological sciences, and at least 18 in geology and mineralogy are required. Students who have taken somewhat less than the indicated minimum in these subjects may be admitted but must make up their deficiencies concurrently with their graduate studies.

Students may be accepted with a previous degree in geophysics, physics, mathematics, engineering, earth sciences, or a closely allied field. Students whose grade-point average in courses pertinent to geology is below 3.00 will be considered for admission when there are strong indications that this average can be maintained at the graduate level. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

GEOLOGY (GEOL)

400.	SURFACE GEOLOGICAL PROCESSES FOR TEACHERS (3)	*Mr. Weber*
401.	EARTH HISTORY FOR TEACHERS (3)	*Mr. Cuffey*
402.	FIELD METHODS FOR TEACHERS (3)	*Mr. Guber*
410.	STRUCTURAL GEOLOGY (3)	*Mr. Gold*
420.	(Biol. 420) PALEOBOTANY (3)	*Mr. Spackman*
421.	INTRODUCTION TO COAL PETROLOGY (3)	*Mr. Spackman*
423.	(Biol. 423) INTRODUCTORY PALYNOLOGY (3)	*Mr. Traverse*
430.	PALEONTOLOGY (3)	*Mr. Guber*
440.	MARINE GEOLOGY (3)	*Mr. Schmalz*
451.	ECONOMIC GEOLOGY (3)	*Mr. Ridge*
452.	INTRODUCTION TO HYDROGEOLOGY (3)	*Messrs. Langmuir and Parizek*
453.	MECHANICS OF GEOLOGICAL MATERIALS (3)	*Mr. Voight*
461.	GEOLOGY OF NORTH AMERICA (3)	*Mr. Wright*
462.	PRINCIPLES OF GEOMORPHOLOGY (3-6)	
470.	INTRODUCTION TO FIELD GEOLOGY (3)	*Mr. Wright*
471.	(Gchem. 471) FIELD STUDIES IN NORTH AMERICA (3)	*Mr. Cuffey*
472.	FIELD GEOLOGY (5)	*Mr. Gold*
481.	GEOLOGY OF OIL AND GAS (3)	*Mr. Scholten*
490.	STRATIGRAPHY (4-7)	*Mr. Williams*

*500. Geology Seminar (1-9) Presentation, at weekly departmental meetings, of topics selected from geological literature. *Messrs. Guber and Williams*

502. (Gchem. 502) Carbonates in the Marine Environment (3) Ancient carbonate rocks and recent carbonate sediments, with emphasis on modern field and laboratory methods and a multidisciplinary approach. *Mr. Weber*

†503. Paleontology (3-9) Morphology of animal groups significant for their fossils; nature of species and faunal zones. Seminars may be arranged for studies of special fossil groups, microfossils, paleoecology. *Mr. Cuffey*

504. History and Foundations of Geology (2-4) Theoretical aspects of geology; spatio-temporal organization of matter, dynamic processes, sequential development; basic patterns and history of scientific thought. *Mr. Williams*

‡506. Sediments of the World (2-6) Evolution of sediments from Archean to Recent; relationship of sedimentation to geotectonism; kratonic and geosynclinal sediments; cyclicity. Prerequisites: Min. 512, 514. *Messrs. Scholten and Williams*

507. Seminar in Geomorphology (3-6) Classic and current literature in geomorphology.

511. Ore Deposits: Principles (3-6) Geological and geochemical processes controlling ore deposition; genetic classification of ore deposits. Prerequisite: Geol. 451. *Mr. Ridge*

512. Ore Deposits: Types (1-6) Geologic history and field examination of selected ore bodies; forming media; causes, sequences, and loci of emplacement; wall rock alteration; secondary enrichment. Prerequisite: Geol. 511. *Mr. Ridge*

524. Coal Petrology (1-6) Microscopy, source materials, coalification, constitution, classification of peats, lignites, bituminous coal, anthracite. *Mr. Spackman*

526. (Biol. 526) Problems in Palynology (1-6) Systematics; paleoecological palynology; Paleozoic palynology; Mesozoic and Cenozoic palynology; Pleistocene vegetational history. *Mr. Traverse*

530. Geological Problems (1-15) Prerequisite: 10 credits in geology and mineralogy.

540. Chemical Oceanography (3) Chemical reactions in sea water and at the sea floor related to sedimentation and diagenesis. *Mr. Schmalz*

545. Glacial Geology (3) Glaciers: their characteristics, causes, deposits, landforms, effects in periglacial regions. *Mr. Parizek*

546. Principles of Photogeology (3) Use of aerial photographs and mosaics in structural, geomorphic, and rock distribution studies and in compilation of maps. Prerequisites: Geol. 410, 462.

551. Dynamic Structural Geology and Geotectonics (3-6) Phenomena of fracturing, faulting, folding; stress and (finite) strain analysis, physical and analytical models; deformational environments; tectogenesis and orogenesis. *Messrs. Scholten and Voight*

555. Advanced Structure and Petrofabrics (1-3) Macroscopic and mesoscopic recognition, measurement, and interpretation of small-scale rock structures and mineral orientation patterns in deformed rocks. *Mr. Gold*

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* Credits to be arranged, 1 to 6 per term.
† Credits to be arranged, 3 to 6 per term.
‡ Credits to be arranged, 2-3 per term.

571. Habitat of Oil (3) Geologic setting of petroleum as determined by basin tectonism, sedimentation, hydraulic and capillary forces, and reservoir textures. *Mr. Scholten*

590. Geology Field Trip (1 per year) Field study of regional geologic features with trips in successive years to differing geologic provinces.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in geological studies are listed under Mineralogy.*

GEOPHYSICS (GPHYS)

Shelton S. Alexander
In Charge of Graduate Programs in Geophysics
204 Mineral Sciences Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Bell and Howell, Associate Professor Alexander.

Graduate Faculty, Associate Members: Assistant Professors Greenfield and Lavin.

Students may specialize in seismology, physical properties of rocks, geophysical surveying, geomagnetism, paleomagnetism, geoelectricity, gravity, wave propagation, time-series analysis, space applications of geophysics, tectonics, earth physics, and planetary sciences.

The language and communications requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages or by comprehensive knowledge of one.

For admission an applicant is generally expected to have had mathematics through differential equations; a standard introductory course each in physics, chemistry, and earth sciences; and at least 16 credits of intermediate-level work in any one or a combination of these subjects. Applicants who have taken somewhat less than the indicated minimum in these subjects may be admitted but must make up their deficiencies concurrently with their graduate studies.

Students may be accepted with a previous degree in geophysics, physics, mathematics, engineering, earth sciences, or a closely allied field. Students whose grade-point average in courses pertinent to geophysics is below 3.00 will be considered for admission when there are strong indications that this average can be maintained at the graduate level. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

The no-thesis option is available for the M.S. degree.

GEOPHYSICS (GPHYS)

400. Physics of the Earth for Teachers (3) *Mr. Lavin*
406. Physics of the Earth (3) *Mr. Graham*
407. Well Logging (3)
408. Geophysical Surveying (3) *Mr. Lavin*
415. Gravity and Magnetic Surveying (3) *Messrs. Lavin and Greenfield*
416. Electrical Surveying (3) *Messrs. Greenfield and Lavin*
417. Seismic Methods (3) *Mr. Lavin*
418. Potential Theory Applied to Earth Problems (3) *Mr. Alexander*

500. Geophysical Seminar (1 per term) Discussion of geophysical reports and papers; scientific outlook.

501. Research (1-10 per term) Research in geophysics.

502. Seismic Instruments (3) Characteristics and design of seismometers and seismic recorders.

503. Special Studies in Geophysics (1-9) Special studies of the theories of geophysical methods.

504. Communication Theory for Geophysicists (3) Basic theory of random processes leading to and including optimum filters; geophysical applications to gravity and seismic data analysis.

507. Seismology (3) Nature and transmission of seismic waves; cause and occurrence of earthquakes; applications in seismic prospecting.

508. Tectonics (3) Seminar in the cause and nature of the principal deformations of the earth.

516. Introduction to Nuclear Processes in Geologic Settings (2) Natural radioactivity and its measurement, interpretation, and use in research and exploration.

521. Thermal State of the Earth (2) Methods and instrumentation of geothermal measurements; geothermal observations; development of the theory of the thermal state of the earth.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in geophysical studies are listed under Materials Science and Mineralogy.*

GERMAN (GER)

Stanley R. Townsend, *Head of the Department*
S-323 Burrowes Building

Degrees Conferred: Ph.D., M.A., M.Ed.

Graduate Faculty, Senior Members: Professors Ebbinghaus, Shelley, and Townsend; Associate Professor Preisner.

Graduate Faculty, Associate Members: Professor de Levie, Associate Professors Kopp and Timpe.

There is opportunity for major emphasis upon either literature or philology. The language and communications requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages.

Minimum qualifications for admission include 24 undergraduate credits in German beyond the intermediate level; provision is made, however, for admission with limited deficiencies. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Students may qualify for the M.A. and M.Ed. degrees either by writing a thesis—which is recommended if a student wishes to be considered for Ph.D. candidacy—or by submitting an essay to the department and taking additional 500-level German courses in lieu of 6 credits of thesis research.

GERMAN (GER)

401. Advanced Stylistics (3)
411. The Teaching of German (3)
430. History of the German Language (3)
443. (C.Lit. 443) Literary Relations of Germany with England and America (3-9)
454. Literature from the Age of Chivalry to the Thirty Years' War (3)
464. Literature from the Beginning of the Enlightenment Through Storm and Stress (3)
469. Goethe's Life and Works (3)
474. Classicism and Romanticism (3)
484. Literature from Realism to Expressionism (3)
495. Independent Study (1-9)

*1G. Elementary German for Graduate Students (3) Designed for students preparing to satisfy language requirements for advanced degrees.

*2G. Elementary German for Graduate Students (3) Continuation of Ger. 1G with opportunity for reading in special fields.

500. Bibliography and Research Techniques (3) Introduction to tools and methods of research, designed for students preparing for independent investigation of problems in German literature and language.

520. Introduction to Middle High German (3) Descriptive and historical grammar; readings in simple Middle High German texts.

521. Readings in Middle High German (3) Intensive reading in Middle High German literature, especially of the *Blütezeit.* Prerequisite: Ger. 520.

522. Old High German (3) Essentials of the grammar with special treatment of the High German sound shift and of ablaut and umlaut; reading of works written before 1100 A.D.

523. Gothic (3) Introduction to the historical and comparative Germanic grammar; emphasis on the Gothic language and texts. Suitable for advanced students in English.

525. Old Icelandic (3) Introduction to Old Icelandic grammar; readings in Old Icelandic prose. Suitable for advanced students in English.

531. Seminar in Medieval German Languages and Literatures (3-6)

541. Seminar in the Literature of the Reformation and Baroque (3-6)

551. Seminar in the Literature of the Enlightenment and the Age of Goethe and Schiller (3-6)

561. Seminar in Post-Idealistic Literature (3-6)

571. Seminar in Modern German Literature (3-6)

581. Seminar in Literary Genres (3-12) Special studies in the German lyric, drama, short story, and novel.

591. Seminar in German Literary Criticism (3)

595. Independent Study (1-9) Selected projects in the study of German literature and philology. Prerequisite: Ger. 500.

* No graduate credit is given for this course.

HIGHER EDUCATION (HI ED)

Larry L. Leslie
In Charge of Graduate Programs in Higher Education
319 Rackley Building

Degrees Conferred: D.Ed., M.Ed.

Graduate Faculty, Senior Members: Professors Anderson, Ikenberry, Lutz, Sweitzer, Willower, and Yamamoto.

Graduate Faculty, Associate Members: Professor Godbey; Associate Professors Flexner, Giusti, Leslie, and Lindsay; Assistant Professor Mortimer.

The graduate program in the higher education major has as its goal the preparation of individuals who will pursue careers as administrators, faculty, or researchers in the nation's colleges and universities and in a variety of public and private agencies and associations. With emphasis on the systematic study of higher education, the program builds on the scholarly and scientific disciplines offered throughout the University and applies these studies to the professional functions and responsibilities which its graduates will assume.

With mounting awareness of the need for educational reforms and for improved teaching, other departments throughout the University encourage their graduate students to pursue a minor in higher education. The higher education faculty cooperates in this program—which is administered through the students' major departments—by offering a number of courses and seminars designed to promote understanding of post-secondary-school teaching.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission to the master's program; a grade-point average of 3.50 for master's work completed is required for admission to the doctoral program. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Some outstanding students may be admitted to the doctoral program with only the baccalaureate degree, but will earn the master's degree *en route.* For special requirements in the higher education major, write: Higher Education, The Pennsylvania State University, 319 Rackley Building, University Park, Pennsylvania 16802.

HIGHER EDUCATION (HI ED)

545. Higher Education in the United States (2-3) A basis for all courses in higher education. Current issues are analyzed and trends of the future anticipated.

546. The Principles of College Teaching (2-3) Principles involved in teaching at the college level; effective use of teaching aids; criteria used in evaluation.

547. Internship in Higher Education (1-9) Supervised experience in administrative offices, in research, on instructional teams, and in college teaching.

548. Curriculums in Higher Education (2-3) Various types of curriculums and philosophies underlying them; ways in which curriculums are developed; elective versus required courses; evaluation of achievement.

549. Community Junior College and the Technical Institute (2-3) Distinctive contributions to meeting the need for post-secondary education; development, functions, curriculum and instruction, government, administration and finance.

550. The Professions and the Education of Teachers (3) The nature of a

profession and dimensions of professional education in the United States are explored. Trends and issues examined.

552. Administration in Higher Education (2-3) Philosophy of administration; principles of scientific management and their application in colleges and universities; case studies of administrative problems. Prerequisite: courses or experience in higher education.

554. The History of American Higher Education (3) An examination of the development of American higher education against the background of influential social, political, economic, and intellectual issues.

555. Seminar in Higher Education (1-6) Special topics in higher education.

556. College Students (3) Characteristics of college students; changes during college years; educational challenges and responses. Prerequisites: Hi.Ed. 545, Psy. 426, I.F.S. 435 or permission of instructor.

589. Problems, Projects, and Area Studies in Higher Education (1-6) Independent work in the study of topics in higher education, or development of new curriculums, materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of the department head.

HISTORY (HIST)

Kent Forster, *Head of the Department*
210 Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty, Senior Members: Professors Brown, Dahmus, Forster, Hassler, Klein, McNall, Murray, Sun, and Utechin; Associate Professors Eggert, Frantz, and Maddox.

Graduate Faculty, Associate Members: Professor Green; Associate Professors Ameringer, Enteen, Linker, Meier; Assistant Professors Borza, Goldschmidt, Silverman, Spielvogel, and Stebbins.

Graduate work is offered in the following areas of history: ancient, medieval, Europe since 1500, Great Britain and the British Empire, Russia and Eastern Europe, the Middle East, the Far East, the United States, and Latin America. These areas are subdivided into chronological, national, and topical fields.

The candidate for the M.A. or M.Ed. degree selects one of the above areas for his master's examination. He must take some courses in an area in history other than his examination area and in a cognate field. (The cognate field for an M.Ed. candidate must be in education.) With the consent of his adviser, a master's candidate may substitute additional course work and a paper for a thesis.

The candidate for the doctor's degree must pass examinations in one of the above areas, in a thesis field within that same area, and in one field from a second area. He must also pass an examination in a single cognate field, or in a study area made up of a number of academic disciplines related to the subject of his thesis. The language and communications requirement may be satisfied by a reading knowledge of two foreign languages or one language and work in quantitative techniques. The D.Ed. candidate has no foreign language requirement; however, he must minor in education.

The entering student should present evidence of undergraduate course work covering the history of Europe from ancient times to the present and the history of

America from its discovery to the present. Students with a 3.00 junior-senior average and better than a 3.00 average in all undergraduate history courses and appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Each applicant must provide Graduate Record Examination scores and at least three letters of recommendation.

HISTORY (HIST)

400. Selected Topics in History (3-6)
401. Classical Civilization (3) *Messrs. Borza and Gregory*
403. The Middle Ages from Constantine to the Crusades (3) *Mr. Dahmus*
404. The Middle Ages from the Crusades to the Renaissance (3) *Mr. Dahmus*
405. Byzantine Civilization (3) *Mr. Gregory*
408. Intellectual History of the Middle Ages (3) *Mr. Dahmus*
410. The Renaissance (3) *Mr. Spielvogel*
411. The Reformation (3) *Mr. Spielvogel*
413. The Age of Absolutism (3) *Mr. Green*
414. The French Revolution and the Napoleonic Era (3) *Mr. Green*
417. Nineteenth Century Europe (3) *Mrs. Rosenblatt*
419. Recent European History (3) *Mr. Foster*
422. History of the American Frontier (3) *Mr. McNall*
425. History of American Political Parties (3) *Mr. Stein*
426. The Diplomatic History of the United States to 1900 (3) *Mr. Maddox*
427. The Diplomatic History of the United States Since 1900 (3) *Mr. Maddox*
428. American Military History (3) *Mr. Hassler*
430. Colonial America to 1753 (3) *Mr. Frantz*
431. Revolutionary America, 1753-1783 (3) *Mr. Frantz*
432. The Formative Period of American History (3) *Mr. Brown*
433. The Middle Period of American History (3) *Mr. Klein*
434. The United States in Civil War and Reconstruction (3) *Mr. Hassler*
435. The Emergence of Modern America (3) *Messrs. Eggert and Stein*
436. America Between the Wars (3) *Mr. Murray*
437. Recent American History (3) *Mr. Murray*
439. History of England in the Middle Ages (3) *Mr. Dahmus*
440. Britain Under the Tudors and Stuarts, 1485-1688 (3) *Mr. Linker*
441. Great Britain, 1688-1832 (3) *Mr. Linker*
442. History of Russia to 1700 (3) *Mr. Utechin*
443. Imperial Russia, 1700-1917 (3) *Mr. Utechin*
444. Eastern Europe in Modern Times (3) *Mr. Enteen*
447. Social and Economic History of Europe Since 1750 (3) *Mr. Silverman*
448. Intellectual and Cultural History of Modern Europe (3) *Mrs. Knight and Mr. Silverman*
449. Diplomatic History of Europe Since 1870 (3) *Mr. Foster*
452. Social and Cultural History of the United States Since 1783 (3) *Mr. Brown*
453. American Economic History in the Agricultural Era (3) *Mr. McNall*
454. American Economic History in the Industrial Era (3) *Mr. Eggert*
456. (L.M.R. 456) History of American Labor (3) *Mr. Eggert*
458. Constitutional History of the United States to 1877 (3) *Mr. Stebbins*
459. Constitutional History of the United States Since 1877 (3) *Mr. Stebbins*
460. Latin America and the United States (3) *Mr. Ameringer*
461. Social and Cultural History of Latin America (3) *Mr. Garner*

462. Mexico and the Caribbean Nations in the Twentieth Century (3) *Mr. Ameringer*
463. Spanish Conquest of the New World (3)
464. Latin American Independence Movements (3)
467. Alexander the Great and the Hellenistic World (3) *Mr. Borza*
468. The Roman Republic (3) *Messrs. Borza and Gregory*
469. The Pax Romana (3) *Mr. Gregory*
470. The Later Roman Empire (3) *Mr. Gregory*
471. Nineteenth Century China (3) *Mrs. Sun*
472. Twentieth Century China (3) *Mr. Duiker*
479. Modern Vietnam, Laos, and Cambodia (3) *Mr. Duiker*
480. History of Arabic Civilization, 600-1258 (3) *Mr. Goldschmidt*
481. The Ottoman Empire and Other Muslim States (3) *Mr. Goldschmidt*
482. The Contemporary Middle East (3) *Mr. Goldschmidt*
491. History of the Soviet Union (3) *Mr. Enteen*
492. Great Britain Since 1832 (3) *Mr. Linker*
497. Germany Since 1640 (3) *Mr. Silverman*

501. Historical Method (3) *Mr. Meier*

502. Historiography (3) *Mr. Meier*

503. Studies in Medieval English History (3-6) A seminar in the political, economic, and cultural history of England in the Middle Ages. *Mr. Dahmus*

504. Medieval Civilization (3-9) *Mr. Dahmus*

505. The Age of the Reformation (3-6) *Mr. Spielvogel*

507. Studies in European History, 1600-1750 (3-6) *Mr. Green*

508. Studies in European History, 1750-1900 (3-6) *Mr. Silverman*

509. Studies in Twentieth Century Europe (3-6) *Mr. Forster*

512. Studies in Pennsylvania History (3-6) *Mr. Klein*

520. Colonial and Revolutionary America (3-6) *Mr. Frantz*

533. The United States, 1783-1860 (3-6) *Mr. Klein*

534. The United States, 1860-1877 (3-6) *Mr. Hassler*

535. The United States, 1877-1919 (3-6) *Mr. Murray*

536. The United States Since 1919 (3-6) *Mr. Murray*

538. Diplomatic History of the United States (3-6) *Mr. Maddox*

539. Economic History of the United States (3-6) *Messrs. McNall and Eggert*

540. Studies in British History (3-6) *Mr. Linker*

544. Seminar in Eastern European History (3-6) *Messrs. Utechin and Enteen*

545. Studies in Russian and Soviet History (3-6) *Messrs. Utechin and Enteen*

550. Problems in History (3-6)

552. Cultural History of the United States (3-6) *Mr. Brown*

559. Studies in Constitutional History (3-9) A graduate seminar examining constitutional developments in their historical context through readings, class discussions and research papers. *Mr. Stebbins*

562. Seminar in Latin-American History (3-6) *Mr. Ameringer*

563. Studies in the History of the Caribbean Area (3) Prerequisites: Hist. 22, 23. *Mr. Ameringer*

568. Studies in Greek History (3-6) *Mr. Borza*

569. Studies in Roman History (3-6) *Mr. Borza*

571. Studies in Asian History (3-9) *Mrs. Sun*

581. Studies in Middle Eastern History (3-6) *Mr. Goldschmidt*

HOME ECONOMICS EDUCATION (HE ED)

Marjorie East, *Head of the Department*
212 Rackley Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Member: Professor East.
Graduate Faculty, Associate Members: Professor Ray, Associate Professor Shear.

Research and graduate courses may be chosen to give emphasis to special areas of interest in home economics education, such as curriculum development; evaluation; teaching at the elementary, secondary, adult, or higher education levels; supervision; administration in colleges; or research.

The language and communications requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign languages.

Students who have majored as undergraduates in some aspect of home economics and who have achieved a grade-point average of at least 2.50 in their junior and senior years will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. Students wishing to be admitted to the doctoral programs must have completed a master's degree, must present a score on the Miller Analogies Test, and will be admitted subject to limitations of departmental facilities. Exceptions will be made for students with special backgrounds, abilities, and interests.

HOME ECONOMICS EDUCATION (HE ED)

400v. Special Problems in Home Economics Education (1-3)
406v. Audio-Visual Methods for Home Economics (1-4)
410v. Supervision of Student Teachers (1-3)
427v. Teaching Home Economics (3)
443v. Adult Education in Home Economics (3)
463v. Senior Seminar (2)
466v. Student Teaching (9)
477v. Curriculum Development for Home Economics in Secondary Schools (3)
478v. Appraising Student Progress in Home Economics (3)
479v. Readings in Home Economics Education (1-4)
480v. Problems in Teaching Home Economics (3-6)
481v. Employment Preparation Programs in Vocational Home Economics (3)

502, 502v. Home Economics Instruction at the College Level (3) Teaching techniques suitable for college instruction in home economics; for prospective home economics college teachers.

503, 503v. Home Economics Teacher Education (3) Organization of college programs of teacher education; use of resources; records; field services; recruitment and selection of personnel. Prerequisite: two years' experience in teaching home economics.

504, 504v. Educational Issues and Home Economics (3) Contemporary issues in education and their relationship to the teaching of home economics. Prerequisite: teaching experience.

510, 510v. Educational Leadership in Home Economics (2-6) Principles of educational leadership for home economics preparing for administration; supervision of city and state programs; supervision of student teachers. Prerequisites: graduation from a four-year teacher education major and two years' teaching experience in home economics.

511, 511v. Internship in Home Economics Supervision and Administration (2-8) Opportunity to understudy an educational leader in student teacher supervision, state supervision, department or college administration, or regional consultation. Prerequisite: H.E.Ed. 510.

518, 518v. Evaluation of Home Economics Programs (3) Methods of evaluating progress toward goals in home economics education and use of findings in program planning and revision.

521, 521v. Home Economics Education Seminar (2-3) Selected topics and recent developments in home economics education. Conferences and guidance relative to individual research problems.

530, 530v. Problems in Home Economics Education (1-6 per term) Individual investigation of problems related to the teaching, supervision, or administration of home economics education.

HORTICULTURE (HORT)

Darrell E. Walker, *Head of the Department*
103 Tyson Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty, Senior Members: Professors Grun, Hitz, Larson, Meahl, Ritter, Smith, Tukey, and Walker; Associate Professors Bergman, Creech, McArdle, and Stinson.

Graduate Faculty, Associate Members: Professor Mastalerz; Associate Professors Haramaki, Kuhn, Martsolf, Pfahl, and White; Assistant Professor Craig.

Students may specialize in propagation, several phases of production, fruit and vegetable processing, plant genetics and breeding, plant nutrition, and various environmental and post-harvest physiological studies of horticultural crop species.

The language and communications requirement for the Ph.D. degree may be satisfied by one of three options: (1) comprehensive competence in one language, (2) reading examination or two course sequence in two languages, or (3) reading examination or two course sequence in one language plus 6 credits in other communications skills.

Students wishing additional credits in floriculture, olericulture, ornamental horticulture, plant breeding and genetics, plant nutrition, or pomology should register for Hort. 501.

Prerequisites for admission vary according to the area of specialization; but basic courses in physical sciences, mathematics, and biological sciences are required. Students who lack prerequisite courses may be admitted but are required to fulfill deficiencies without degree credit.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

HORTICULTURE (HORT)

401. Plant Propagation (3) *Mr. Haramaki*
402. Plant Nutrition (3) *Mr. Bergman*
403. Horticultural Plants and Their Environment (3) *Mr. Mastalerz*
404. Advanced Horticultural Crop Science (3-12) *Mr. Walker*
405. Senior Seminar in Horticulture (1-2)
407. Plant Breeding (3) *Mr. Hepler*
412. Post-Harvest Physiology (3) *Mr. Ritter*
444. Advanced Plant Breeding (3-6) *Mr. Craig*
447. Problems in Horticulture (1-9)
451. Flower Store Management (4) *Mr. Pfahl*

501. Experimental Problems in Horticultural Science (1-12) Investigation of problems in floriculture, olericulture, ornamental horticulture, plant breeding, nutrition, or pomology. *Mr. Walker*

506. Nutrition of Horticultural Crops (2-4) Principles, applications, and interpretations of diagnostic methods for determining fertilizer requirements of horticultural crops. *Mr. Smith*

512. Principles of Fruit and Vegetable Storage (2-4) Principles involved in the maturation, storage, and senescence of fruits and vegetables, and their application. Winter term, odd years. *Mr. Ritter*

514. Propagation and Improvement of Horticulture Plants (1-6) Biological factors affecting sexual and asexual propagation of plants; techniques in plant improvement; maintenance of propagation material. *Mr. Meahl*

517. Horticultural Seminar (1 per term) Review of current research publications in horticulture. Each student presents one or more reviews of assigned topics.

520. Genetics and Breeding Seminar (1 per term) Review of research and literature in genetics and breeding of horticultural crops.

524. Experimental Procedures in Horticultural Research (3) *Mr. Craig*

525. Horticultural Research Techniques (3) Practice in and comparison of methods and apparatus used in horticultural research. Winter term, even years. *Mr. Tukey*

528. Problems in Fruit and Vegetable Processing (2-12) *Mr. McArdle*

HUMAN DEVELOPMENT AND FAMILY STUDIES (HD FS)

JOSEPH H. BRITTON
In Charge of Graduate Program in Human Development and Family Studies
S-105E Human Development Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors Britton, de Lissovoy, Gottlieb, B. Guerney, Harms, Harris, Knoll, Smith, G. F. Stover, Taylor, and Urban; Associate Professors Bortner and Nichols.

Graduate Faculty, Associate Members: Associate Professor Gage; Assistant Professors Hultsch, Peters, Stein, L. Stover, and Vondracek; Mrs. L. Guerney.

The graduate program in Human Development and Family Studies is concerned with interdisciplinary study of individuals and families and with ways in which their development and welfare can be promoted. The perspective encompasses the individual life span, the life cycle of the family, and the changes which occur with time. It includes variations in patterns of functioning and the use of resources; the impact of diverse social, economic, and cultural contexts upon behavior; and conditions as well as professional procedures which bring about positive and constructive development. Emphasis is upon the integration of knowledge from various fields for the purposes of understanding and developing professional skills for careers in research and scholarship, in teaching, in program planning and evaluation, or in other professional services. The faculty includes persons in the behavioral and social sciences particularly committed to research and application in these interdisciplinary areas.

The student is expected to include courses in both individual development and family studies and is expected also to emphasize one area of study or professional orientation. He may specialize in research and teaching in the area of the family—family relationships or family economics and management; or in infant, child or adolescent development; or in adult development and aging. He may be preparing for professional work as a consultant on individual, family, or community problems; for a leadership role in developmental and educational programs for children, adolescents, or adults.

The Division of Individual and Family Studies operates infant and preschool laboratories as part of the teaching and research program. Each unit has observational facilities, and there are adjoining rooms for study of individual and group behavior of children and adults. Home management houses provide opportunities for research and for guiding undergraduate students in an experience in group living and in managing household resources. The Individual and Family Consultation Center provides facilities for the development and evaluation of educational programs for remediation of individual and family problems by professional and paraprofessional persons. Additional resources, such as the Psychology Clinic, the Special Education Center for Children, the Speech and Hearing Clinic, the Division of Counseling, and the Computation Center, are available in other parts of the University.

The language and communications requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign languages.

Entering students should have at least 6 credits in the biological and physical sciences, 12 in the social sciences (and, depending upon proposed area of emphasis, basic courses in sociology, psychology, and economics), and 6 in developmental and family studies. Students not meeting these requirements may be admitted with limited deficiencies to be made up concurrently with their graduate work.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

CHILD DEVELOPMENT AND FAMILY RELATIONSHIPS (CD FR)

500. Nonthesis Research (1-9)

508. Parental Education (3) Discussion and use of methods, experiences, and programs which can be used effectively to help parents in dealing with problems of parent-child relationships.

515. The Teaching of Child Development and Family Relationships (3) Methods of selection and presentation of subject matter basic to understanding the development of children.

520. Infancy (3) Infant development, with emphasis on factors influencing development and the relationships of early experience to later behavior. Prerequisites: 6 graduate credits in child development and family relationships, psychology, or biological sciences and 3 credits in statistics.

530. Problems in Child Development and Family Relationships (1-9) Problems involving individual research in library, laboratory, or field projects.

545. The Family in Its Community (3) Cultural influences on family relationships; how the family orients its members to community living and group participation.

546. Seminar in Family Relationships (1-9) Reading, reports, and discussion of recent research in relationship aspects of family living; particular attention to studies of roles, crises, and adjustments within the family setting.

548. Survey of Research on Sexual Behavior (3) Survey and evaluation of the contributions of the studies of sex by H. Ellis, Freud, Malinowski, Terman, Kinsey, and others. Prerequisites: 12 credits at the 400 and 500 level in child development and family relationships, psychology, sociology, or anthropology; 3 credits in statistics.

550. Perspectives in Child Development (3) Analysis of developmental studies since 1920. Examination of childhood in philosophy, education, literature, and art prior to 1920. Prerequisites: 6 graduate credits in psychology or child development and family relationships and 3 credits in statistics.

579. Seminar in Adult Development and Aging (1-9) A seminar dealing with specific topics concerning adult development and aging. Prerequisites: I.F.S. 445 and statistics.

FAMILY ECONOMICS AND HOME MANAGEMENT (FE HM)

515. Consumer Problems (2-3) Methods of securing, evaluating, and presenting data concerning household commodities. For home economics in high schools, colleges, and adult classes.

524. Economic Problems of the Household (3) Economic problems of the present-day family; special emphasis on factors in household production, use of money income, and standards of living.

528. Home Management Supervision (2-3) Evaluation of objectives and tech-

niques in organization, supervision, and teaching of the home management house experience.

543. Home Management in Relation to Family Living (3) Includes work with families in solution of their management problems.

544. Problems in Family Economics and Home Management (1-6) Investigation of selected problems in family economics and home management.

550. Seminar in Family Economics and Home Management (1-6) Discussion and reports on developments in family economics and home management.

INDIVIDUAL AND FAMILY STUDIES (I F S)

410. Communities and Families (3)
411. The Helping Relationship (3)
413. Dysfunctions in the Developmental Process (3)
414. Resolving Individual and Family Problems (3)
415. Child Development and Family Relationships for Secondary Schools (3)
416. (C.S. 416) Consumer Role of Family (3)
418. Family Relationships (3)
419. Problems of Family Financial Management (3)
420. Problems in the Analysis of Individual Development (3-9)
424. Economic Conditions in Relation to the Family (3)
427. Conceptions in Development (3)
428. Infant Development (3)
429. Advanced Child Development (3)
430. Practicum in Preschool Groups (1-6)
432. Developmental Problems of Normal Children (3)
435. Developmental Transition to Adulthood (3)
439. Family Resource Management (2)
441. Organization Planning for Preschool Programs (3)
442. Home Management Experience (3)
445. (Psy. 445) Development Throughout Adulthood (3)
477. Analysis of Family Problems (2-9)
481. Developmental Programming for Preschool Children (3)

529. (Psy. 529) Seminar in Child Development (1-6) Readings and reports on recent findings in child development. Prerequisites: 6 graduate credits in child development, child psychology, or educational psychology, plus 3 in statistics.

536. (Psy. 536) Research Methods in Developmental Processes (3) Methodological issues in research on varying stages of development across the individual life-span. Prerequisites: 6 credits in individual development or psychology and a course in statistics.

549. (Psy. 549) Developmental Theory (3) Conceptual frameworks and major contributions to the study of individual development across the life-span. Prerequisite: 6 credits at the 400 level in individual development or psychology.

HUMANITIES (HUMAN)

NANCY M. TISCHLER
In Charge of Graduate Programs in Humanities
Capitol Campus, Middletown, Pennsylvania 17057

Degree Conferred: M.A.

Graduate Faculty, Senior Members: Professors Lear and G. Wolf, Associate Professor Chen.

Graduate Faculty, Associate Members: Professors Knight, McAree, and Tischler; Associate Professors Dordevic, Jordan, Richman, and M. Wolf.

This program aims at developing skills in the interdisciplinary study of art, music, literature, and philosophy. Entering students are expected to have considerable background in at least two of those areas. A committee will meet with each student to determine his individual needs and arrange a program designed to help him develop essential skills, such as analysis and criticism of music, art, literature, and philosophy; classification of works into genres, periods, and schools; evaluation of works by applications of appropriate criteria; and synthesis and generalization. For students who plan to teach in a junior college, there is also provision for an internship program.

A series of seven 500-level courses are designed to help a student develop a number of these skills. In addition, his adviser may suggest he enroll in certain 400-level courses or in independent studies with qualified faculty.

Each student is required to submit a master's production (a critical paper or a creative work accompanied by a paper) which will demonstrate his competence in humanistic study. A committee will judge this production.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

This program is available only at the Capitol Campus.

HUMANITIES (HUMAN)

500. RESEARCH METHODS (3) Study of the methods and materials of scholarship, compilation of bibliographies, writing of scholarly papers, and proper documentation.

501. PRESUPPOSITIONS IN THE HUMANITIES (3) Assumptions about knowledge, reality, and value which influence the humanist in his choice of ideas, methods, and modes.

502. PERENNIAL ISSUES IN THE HUMANITIES (3) Recurrent issues viewed in terms of their significance to the artist, historian, and the philosopher.

503. INTERRELATIONS IN THE HUMANITIES (3) An interdisciplinary study of the interdependence of aesthetic values in various art forms as they exist in cultural settings.

520. STUDIES IN STYLE (3) Study of prominent stylistic patterns, evaluating the essence of a style, and the varied responses of the artist and philosopher within a pattern.

525. STUDIES IN AESTHETICS (3) Study of certain techniques in the arts that presuppose certain aesthetic concepts and certain ideas that demand parallel form.

590. MASTER'S PRODUCTION (1-6) An original scholarly master's paper or creative

production initiated by the student, supervised by an appropriate professor, and judged by a committee.

598. Independent Study (3) A course of study not regularly offered which the student and a qualified faculty member design on a tutorial basis.

599. Special Topics (3) Experimental courses in the Humanities.

EDUCATION (ED)

520. Seminar in Junior College Teaching (3) The history of the two-year college, responsibilities of the teacher in the college organization, and methods of teaching.

550. Internship in Junior College (3) Teaching humanities courses in a two-year college under a master teacher, who will direct, criticize, and evaluate the intern.

INDUSTRIAL ARTS EDUCATION (I ART)

Paul W. Bixby
In Charge of Graduate Programs in Industrial Arts Education
168 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Associate Members: Associate Professors Koble and Shemick.

Emphasis may be placed on research, curriculum development, or teacher education. The language and communications requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign languages.

Graduation from an approved major in industrial arts and at least 18 credits in education and related psychology are required for admission. Students with a 2.70 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.70 grade-point average may be made for students with special backgrounds, abilities, and interests.

Graduate Record Examination scores on both aptitude and education sections are required of D.Ed. and Ph.D. candidates.

INDUSTRIAL STUDIES (I S)

400. Planning and Management of Instructional Resources (3)
410. Technology in the Elementary School (3)
440. Independent Study in Industrial Studies (2)
450. Selected Topics in Industrial Studies (1-6)

INDUSTRIAL ARTS (I ART)

574. History and Philosophy of Industrial Arts (2-3) Historical developments and concurrent educational philosophies of industrial arts in American education. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

575. Problems in Industrial Arts Education (2-3) Subject matter, projects,

methods of manual and informational teaching, aids and devices, selection of text and reference materials, personnel organization, shop management, problem pupils. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

576. Supervision and Administration of Industrial Arts Education (2-3) How to organize, supervise, and administer functioning programs of industrial arts; duties of a supervisor and director of industrial arts. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

577. Testing in Industrial Arts (2-3) Construction of informal manipulative and written tests; use of standardized mechanical aptitude and achievement tests; construction and use of rating scales; scoring and gradings; interpretation of test results. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

578. Research in Industrial Arts (2-3) Research techniques in industrial arts education. Prerequisite: 6 credits in professional courses in industrial arts.

580. Seminar in Industrial Arts (1-9) Directed intensive study, investigation or research in selected phases of the program; reports and constructive criticism. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

INDUSTRIAL ENGINEERING (I E)

Benjamin W. Niebel, *Head of the Department*
207 Hammond Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty, Senior Members: Professors Ham, Lancaster, Niebel, and Schmidt; Associate Professors Draper and Rosenshine.

Graduate Faculty, Associate Members: Professors Thuering and Zindler; Associate Professors Addison, Freark, Guild, and Raphael.

Graduate study and research are conducted in operations research-management science, production engineering, process design, systems engineering, and human engineering.

The language and communications requirement for the Ph.D. degree may be satisfied by an intermediate knowledge of one foreign language.

Graduates in industrial engineering, other engineering curriculums and mathematics who present a 2.50 junior-senior average will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

INDUSTRIAL ENGINEERING (I E)

400. Engineering for Production (3)
402. Engineering Economy (3)
403. Engineering Economy and Statistics (3)
404. Management Science (3)
405. Linear Programming (3)
406. Design of Production and Distribution Systems (3)
407. Quantitative Methods for Operations Research (3)

422a,b,c,d,e,f. Industrial Engineering Problems (2-12)
423. Quality Control (3)
424. Job Evaluation (3)
425. Introduction to Operations Research (3)
426. Industrial Automation (3)
427. Solidification of Castings (3)
428. Foundry Engineering (3)
430. Industrial Leadership (3)
432. Introduction to Reliability Engineering (1-3)
438. Metal Cutting Principles and Practice (3)

501. Manufacturing Methods (2-8) Special projects including investigation; experimentation, design, and research of one or more special types of manufacture.

502. Management Methods (3-6) Scientific management, including management controls and mathematical programming; research on special problems.

503. Industrial Relations (1-6) Study of human problems related to labor unions, hierarchy, specialization; analysis of organizational structure, policies, decision criteria, and communication systems.

504. Advanced Quantitative Methods in Industrial Engineering (3) Study of statistical and analytical decision models important in industrial engineering with emphasis on inference and testing of hypotheses. Prerequisites: Math. 62 and 3 credits in statistics.

506. Advanced Work Design and Measurement (3-9) Methods of research in motion and time study; critical analysis of current literature.

507. Analysis of Decision Processes (3-6) An introductory study of decision theory and its applications. Models and analyses of decisions under assumed certainty, risk, and uncertainty. Prerequisites: I.E. 323, 402.

508. Operations Research I (3) The study of deterministic optimization models in operations research including allocation, inventory, sequencing and replacement models. Prerequisite: I.E. 425.

509. Operations Research II (3) The study of probabilistic optimization models in operations research including network, inventory, waiting lines, forecasting and game theory models. Prerequisite: I.E. 425.

510. Mathematical Programming (3) Study of advanced topics in linear programming including duality, decomposition, sensitivity analysis, parametric programming, and selected topics in mathematical programming. Prerequisite: I.E. 405.

511. Experimental Design in Engineering (3) Statistical design and analysis of experiments in engineering; experimental models and experimental designs using the analysis of variance. Prerequisites: Math. 63 and 3 credits in statistics.

512. Graph Theory and Networks in Management Science (3) Prerequisite: I.E. 405.

513. Real Time Data Processing for Engineering Systems (3) Random access computers and communication components for real time systems; engineering systems simulation on digital computers. Prerequisite: Cmp.Sc. 102 or 410.

515. Complex Linear Flow Models (3) Application of complex linear flow models in engineering and management science, including static and dynamic system simulations. Prerequisite: I.E. 512.

516. Applied Stochastic Processes I (3) Prerequisites: I.E. 323, Stat. 418.

517. Applied Stochastic Processes II (3) Prerequisite: I.E. 516.

518. Plastic Deformation Processes (3) Study of the principles, theories, technology, design, and application of plastic deformation processes to shape metals. Prerequisite: undergraduate engineering degree.

528. Metal Cutting Theory (3) Study of the theory of metal cutting, contemporary and future problems of metal removal processes; critical analysis of current literature. Prerequisite: I.E. 438.

538. Experimental Investigations in Materials Processing (3) Experimental investigation on selected subjects in processing involving instrumentation, methods, and analysis. Prerequisite: I.E. 528.

JOURNALISM (JOURN)

Robert M. Pockrass
In Charge of Graduate Programs in Journalism
220 Carnegie Building

Degree Conferred: M.A.

Graduate Faculty, Senior Members: Professors Barnes, Brown, and Harrison.
Graduate Faculty, Associate Members: Professor Goodwin; Associate Professors Dulaney, Froke, Norris, Pockrass, and Smith.

The program is designed to be as responsive as possible to the needs of students who bring to it different undergraduate and/or professional backgrounds. It can give to those students who have had professional training or experience an understanding of the theory and practice of mass communications as well as a critical insight into the structure and functions of mass communications industries and an introduction to research on communications problems. At the same time, it offers students with substantial backgrounds in the social sciences or humanities the opportunity to prepare themselves professionally to enter the media of mass communications or allied fields.

Although an M.A. candidate is normally expected to write a thesis and complete a minor of 12 credits variations from this pattern may be arranged to meet the needs and interests of the individual student.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

JOURNALISM (JOURN)

401. Critics and Ethics of the Mass Media (3) *Mr. Harrison*
405. International Mass Communications (3)
406. Evaluation and Uses of Mass Communications Research (3) *Mr. Colldeweih*
419. (Spch. 419) Comparative Broadcasting Systems (3)
421. Editorial Interpretation (3) *Messrs. Brown and Harrison*
422. Cultural Aspects of the Mass Media (3) *Mr. Pockrass*

424. Public Affairs Reporting (3)
430. Journalism in the Schools (3-6)
436. (Soc. 436) Sociology of Opinion Formation (3)
442. Special Topics in Advertising (3)
443. Advertising Campaigns (3) *Mr. Rotzoll*
444. Advertising in Contemporary Society (3) *Mr. Norris*
460. Photography for the Mass Media (3)
466. Public Relations Problems (3)
468. Law of Mass Communications (3) *Mr. Smith*
470. Reporting of Contemporary Issues (3)
481. News Editing and Evaluation (3)
492. Public Affairs Broadcasting (3) *Mr. Farson*
499. Independent Study in Mass Communication (2-6) *Mr. Goodwin*

504. Seminar in the History of Mass Communication (3) *Mr. Harrison*

505. International Communication Problems (3) Legal and communications problems of the international flow of news and opinion; international press codes.

506. Introduction to Mass Communications Research (3) The scientific method; survey of basic concepts of theoretical and empirical research; variety of methodology; criteria for adequate research. *Mr. Barnes*

508. The Literature of Journalism (3) *Mr. Brown*

510. Mass Communications Research Methods I (3) Design of research on processes and effects of mass communications; data analysis and hypothesis testing. Prerequisite: Journ. 506 or Stat. 400. *Mr. Barnes*

511. Mass Communications Research Methods II (3) Problems of bibliographical research; evaluation of sources and materials in mass communications history, biography, structure, ethics, and other areas. Prerequisite: Journ. 506.

513. Constitutional Problems of the News Media (3) Problems involving conflict between guarantees of press freedom in the First and Fourteenth Amendments and rights and privileges of others. *Mr. Harrison*

521. News Media and Public Opinion (3) Problems in the function, techniques, and responsibilities of press, radio, and television in forming and interpreting opinion. Prerequisite: Pl.Sc. 427. *Mr. Pockrass*

524. Government and Mass Communications (3) Problems of freedom of information; governmental efforts to control mass communication agencies; government news coverage; public information agencies. *Mr. Smith*

540. Seminar in Advertising Problems (3) *Mr. Norris*

545. Advertising and Consumer Behavior (3) Examination of theories of human behavior as they apply to the study of advertising's effects on consumer behavior.

585. Comparative Theories of Press Systems (3) Institutional structure and normative functions of press systems in modern societies, as shaped by prevailing world view and social organization. *Mr. Norris*

LABORATORY ANIMAL MEDICINE (L A M)

C. Max Lang, *Chairman, Department of Comparative Medicine*
The Milton S. Hershey Medical Center

Degree Conferred: M.S.

Graduate Faculty, Associate Member: Associate Professor Lang.

The department offers a postdoctoral program for veterinarians leading to the Master of Science degree with a major in laboratory animal medicine. Laboratory animal medicine is a specialty of veterinary medicine that is concerned with the biology of laboratory animals and their comparative relationships to man. Postdoctoral training in this discipline provides a broad, basic foundation upon which the individual can build a career in teaching and research in laboratory animal medicine and/or in the professional direction of research animal facilities. The program has a strong research-oriented base with emphasis on comparative medicine and pathology.

The program requires two years for completion. Basically, the first year consists of formal course work, while the second year is devoted mainly to research and the development of clinical skills and techniques. A student must have earned a minimum of 12 credits in a major subject, 6 credits in a minor subject, and 6 credits of thesis research in order to receive the graduate degree. Approved minors have been established in anatomy, behavioral science, biological chemistry, microbiology, pathology, pharmacology, and physiology.

Students with a 2.75 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.75 grade-point average may be made for students with special backgrounds, abilities, and interests.

This program is offered only at The Milton S. Hershey Medical Center.

COMPARATIVE MEDICINE (C MED)

501. Biology and Care of Laboratory Animals (2) Presentation of the anatomic and physiologic characteristics of the commonly used laboratory animal species and their relation to biomedical research.

503. Laboratory Animal Genetics (2) Genetic principles applied to laboratory animals used for investigations of diseases that may be controlled or influenced by genetic factors.

505. Laboratory Animal Zoonoses (2) Experimentally induced, spontaneous, and infectious diseases transmissible between man and animals with special emphasis on etiology, differential diagnosis, and control.

507. Techniques of Laboratory Animal Experimentation (2) Techniques of drug administration, infusion, and collection of body fluids and materials; gnotobiology; use of radioisotopes and bioinstrumentation.

510. Animal Physiological Surgery (3) Selected operative procedures, demonstrating principles of physiology with modern biomedical instrumentation, will be followed through the postoperative period.

515. Experimental Surgery of Laboratory Animals (3) Surgical techniques, including nephrectomy and Goldblatt clamp, bladder and gastric pouches, bile duct connulation, intraventricular operation, cardiac and cerebrovascular catheterization.

530. Disease of Laboratory Animals, I (3) Physiological and pathological ex-

pressions of both infectious and metabolic-degenerative disease of rodents, with emphasis on diagnostic and control methods.

531. Diseases of Laboratory Animals, II (3) Physiological and pathological expressions of both infectious and metabolic-degenerative disease of nonhuman primates and other species of animals.

535. Comparative Pathology (3) Comparative pathologic characteristics of infectious and metabolic disease of animals and man.

540. Seminar (1 per term) Student and faculty discussions of organization and presentation of data on recent advances in selected topics of laboratory animal medicine.

570. Special Topics (1-6) Specialized training in advanced research techniques and current status of research in the various areas of laboratory animal medicine.

590. Research Problems (1-12) Research training will be given to enable the student to advance his knowledge about some aspect of laboratory animal medicine.

LINGUISTICS (LING)

Simon Belasco
In Charge of Graduate Programs in Linguistics
309 Burrowes Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty, Senior Members: Professors Belasco, Borden, Brault, Brubaker, Cofer, Ebbinghaus, Hammer, Holtzman, Magner, Morrill, Palermo, Schmalstieg, Sturcken; Associate Professors Dalbor and Singletary.

Graduate Faculty, Associate Member: Assistant Professor Martin.

A student majoring in linguistics may specialize in one of several flexible interdisciplinary graduate programs. The M.A. degree program includes general courses in historical linguistics, generative phonology and syntax, psycholinguistics, and acoustic phonetics. A candidate will also select, with the help of his graduate adviser, a coherent set of electives in a specialized area which may be a language or a related field. He will submit an acceptable master's essay and pass a written comprehensive examination.

In addition to the courses required for the M.A. degree in linguistics (or the equivalent), each candidate for the Ph.D. degree must take the following courses: Ling. 503 if he has selected Ling. 504 or vice-versa, Ling. 505 (Seminar in Historical Linguistics), Spch. 520 (Seminar in Speech Science), and at least two 500-level courses in the structure, phonology, and history of a language or language family other than his native language if he specializes in a related area, and at least five 500-level courses in the related area. If he specializes in a language area, he must take at least two 500-level courses in the structure, phonology, and history of a language or language family other than his native language or language area and at least five 500-level courses in his language area. The specialized area will be selected by the candidate with the approval of his doctoral committee. The doctoral comprehensive examinations will be both written and oral and will cover the synchronic and diachronic aspects of general linguistics as well as the candidate's specialized area. The dissertation must represent a significant contribution to linguistic knowledge. The language and communications requirement for the Ph.D.

degree may be satisfied by intermediate knowledge of either French, German, Spanish, or Russian and another major language related to the candidate's professional interests.

The minimum requirement for admission to an advanced degree program will normally be a B.A. degree in linguistics or an equivalent in any of the interdisciplinary subjects recognized as a specialized area.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

LINGUISTICS (LING)

400. Introduction to Transformation Grammar (3)
402. Historical Linguistics (3)
420. (Psy. 420) Advanced Psycholinguistics (3)

500. Generative Linguistics (3) Types of grammatical rules and their interrelations; algorithm for assigning structural descriptions; evaluation procedure for selecting best compatible grammar.

503. Generative Syntax (3) Grammatical rules specifying well-formed strings; conditions on analyzability and assigning of structural descriptions; deviation from well-formedness. Prerequisite: Ling. 400.

504. Generative Phonology (3) Distinctive feature theory in the generative framework; articulatory and acoustic correlates; nonphonemic features. Prerequisite: Ling. 400.

505. Seminar in Historical Linguistics (3) Detailed study of some problem of historical linguistics, e.g., the laryngeal theory, Indo-European ablaut, etc. Prerequisite: one course in historical linguistics.

520. (Psy. 520) Seminar in Psycholinguistics (3) The relationship between the behavioral, probabilistic view and the structuralist, deterministic view of language as a system of habits.

MAN-ENVIRONMENT RELATIONS (M E R)

Raymond G. Studer, *Director of the Division*
S-126 Human Development Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors Arnold, Jones, Vallance, and Wohlwill; Associate Professors Carson, Densmore, and Esser.

Graduate Faculty, Associate Members: Professor Studer; Associate Professors Coblentz, Mann, and Van Dommelen; Assistant Professor Smith.

Graduate instruction and research opportunities are available in the application of tools and knowledge in the basic sciences to the understanding and organization of various man-environment systems. This broad, interdisciplinary program deals with the effects of man-made environments upon human biological, behavioral, and social outcomes. Included is the development of methodological and empirical resources

required to realize and maintain environmental support systems for various human goals and settings. Students in this program may develop general competences in man-environment relations (environmental analysis and management), or specialize in clothing and textiles and food service and housing. These areas of specialization have been organized under a unifying structure to provide an interdisciplinary, integrative base (see courses 500-503). Specialization in clothing provides an approach to understanding the role and technical requirements of clothing for individuals, families, industries, and nations. Specialization in food service provides professional training for management positions in hospitals, educational systems, and other public and private settings. Specialization in housing provides training for professionals involved in programming, planning, and managing the micro and macro aspects of large-scale housing systems in both the public and private sectors.

Undergraduate preparation may be in one of the above or related areas, in the physical, behavioral or social sciences, or in environmental and urban studies. Deficiencies, assigned on an individual basis, may be removed concurrent with graduate studies. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

CLOTHING AND TEXTILES (CL TX)

400. Special Problems in Clothing and Textiles (1-6)
408. Intermediate Textiles: 408L (2), 408P, (1-3)
410. Clothing for the Family (3)
415. Functional Clothing Design (3-12)
416. Western Costume Development from the Renaissance to the Present (3)

HOUSING AND INTERIORS (H I)

401. Advanced Interiors I (3)
402. Advanced Interiors II (3-9)
470. Housing Problems and Policies (3)

FOOD SERVICE AND HOUSING ADMINISTRATION (FS HA)

402. Food Service and Housing Layout and Design (3)
410. Advanced Quantity Food Production (3)
425. Food and Labor Management and Control (3)
461. Personnel Functions in Food Service and Housing Administration (3)
470. Problems in Food Service and Housing Administration (3)

MAN-ENVIRONMENT RELATIONS (M E R)

500. Nonthesis Research (1-6)

501. Problems in Man-Environment Relations (1-9) Individual directed study, investigation and practice in selected aspects of man-environment relations.

502. Seminar in Man-Environment Relations (1-9)

503. Research Methods and Evaluation in Man-Environment Relations (1-9)

520. Recent Developments in Textiles (3) Developments in fibers, yarns, fabrics, finishes; effects on use and care; discussions and reports based on current literature.

521. Clothing Behavior (3) Analysis and interpretation of clothing behavior through application of theories selected from the behavioral sciences.

522. Clothing Production, Distribution and Consumption Systems (3) Problems connected with manufacture and consumption of clothing; interrelation of textile and clothing trades with other industries.

523. Societal Determinants in Clothing and Textile Development (1-6)

525. Textile Technology (6)

540. The Proximate Housing Environment (3) Evaluation of useful objects in respect to their form, function, and time; selection for exhibition.

541. Aesthetic Aspects of Housing (3) Approach based upon human needs with consideration of materials in the light of their use in home living.

MATHEMATICS (MATH)

Paul Axt, *Head of the Department*
227 McAllister Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty, Senior Members: Professors Anderson, Andrews, Armentrout, Axt, C. Ayoub, R. Ayoub, S. Chowla, Fine, Hammer, Hunter, Kanwal, H. Krall, Petrich, and Ribeiro; Associate Professors Deutsch, Hahn, James, A. Krall, Morris, and Rung.

Graduate Faculty, Associate Members: Associate Professors Lallement, Mack, Maserick, and McCammon; Assistant Professors Grilliot, Kalmbach, McLaughlin, Olson, and Stevens.

Graduate courses in all the principal branches of mathematics are offered regularly each year. The department is prepared to direct research in a variety of fields, including various branches of analysis, algebra, topology, number theory, numerical analysis, applied analysis, and mathematical logic and foundations. A digital computer is available on the campus for students interested in numerical methods.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Entering graduate students in mathematics for whom English is not the first language are required to have a score of at least 450 on the TOEFL (Test of English as a Foreign Language) examination. Furthermore, the results of this examination must be received by the Department of Mathematics at least six months prior to the requested date of admission to the Graduate School.

To be admitted to the Ph.D., D.Ed., or M.A. program without undergraduate deficiency, an applicant should have completed at least 18 credits in mathematics at the advanced undergraduate level (400 series) or their equivalents. The undergraduate student is urged to take at least 6 credits in foundations of analysis (Math. 420-421) and 6 in modern algebra (Math. 480-481) or their equivalents. These courses are essential to prepare for the graduate program and, if they are taken after admission, only 6 credits at most may be counted toward an advanced degree. All first year students working toward the Ph.D., D.Ed., or M.A. degree are required to enroll in Math. 489 for two successive terms.

All Ph.D. students, before they have accumulated 48 graduate credits earned at the University or elsewhere, must take qualifying examinations in three fields of mathematics and demonstrate a reading knowledge of one foreign language (French, German or Russian). Recommendations for advancement to Ph.D. candidacy are based on these examinations. The comprehensive examination is given after approximately 60 credits and only after the student has passed a reading examination in a second of the foregoing languages.

For the D.Ed. degree, a student must pass qualifying examinations in algebra and analysis and a reading examination in French, German, or Russian before he is allowed to take the comprehensive examination. In addition to the major thesis, the department requires participation in two terms of research seminar, but no minor thesis is required.

For the M.A. degree the department offers two options: (1) The *thesis* option requires 12 credits of approved 500-series courses in mathematics, 6-9 credits of thesis, sufficient credits in approved 400- or 500-series courses to make a total of 30 credits, and a final oral examination based on the thesis and general course material, and (2) The *non-thesis* option requires 18 credits of 500-series courses in mathematics with grades of A or B, sufficient credits in approved 400- or 500-series courses to make a total of 30 credits, and a term paper of an approved topic in mathematics. No final examination is given in this option.

To be admitted to the M.Ed. program without undergraduate deficiency, an applicant should have completed at least 15 credits in mathematics at the intermediate level beyond calculus. The M.Ed. program does not require any 500-series courses, but the student is encouraged to select some at this level. Special courses have been instituted for the training of teachers. Among these are Math. 400, 401-402, 415, 416, 425-426, and 470-471. These are acceptable for the satisfaction of credit requirements only for the M.Ed. degree.

MATHEMATICS (MATH)

400. Probability for Teachers (3)
401-402. Geometry for Teachers (3 each)
404. Theory of Numbers (3)
405. (A.M. 405) Fourier Series and Partial Differential Equations (3)
406. Topics in Theory of Numbers (3)
407. Foundations of Algebra and Geometry (3)
409-410. (Stat. 409-410) Introduction to Mathematical Statistics (3 each)
411. Finite Differences (3)
412. (Stat. 412) Introduction to Mathematical Statistics (3)
413-414. Mathematics of Science for Teachers (3 each)
415. Survey of Modern Mathematics for Teachers (3)
416. Mathematical Logic for Teachers (3)
417. (A.M. 417) Tensor Analysis (3)
418. (A.M. 418, Stat. 418) Discrete Probability Theory (3)
420-421. Introduction to Analysis (3 each)
425-426. Analysis for Teachers (3 each)
427. (Stat. 427) Discrete Stochastic Models (3)
428. (Phil. 428) Logical Theory (3)
431. (A.M. 431) Ordinary Differential Equations (3)
435. Axiomatic Set Theory (3)
441. (A.M. 441) Matrix Algebra (3)
452. (A.M. 452) Functions of a Complex Variable (3)
453. (Cmp.Sc. 453) Numerical Computations (3)
454. (Cmp.Sc. 454) Matrix Computations (3)
470-471. Algebra for Teachers (3 each)
472. Foundations of Geometry (3)
473. Elementary Point-Set Topology (3)

480-481. Introduction to Modern Algebra (3 each)
489. Mathematics Seminar (1-6)
490. Topics in Mathematics (3-9)
491. Topics in Applied Mathematics (3-9)

501-502. Theory of Functions of a Real Variable (3 each) Sets, metric spaces, measure and integration, Lp spaces and other function spaces, differentiation. Prerequisite: Math. 421.

503. Fourier Analysis (3) Fourier series and integrals, convergence and summability, theorems on Fourier coefficients, uniqueness properties. Prerequisite or concurrent: Math. 502.

505. Integral Equations (3) Fredholm and Volterra equations, and applications. Prerequisite: Math. 421.

507. Calculus of Variations (3) Prerequisite: Math. 421.

508-509. Complex Analysis (3 each) Analytic and meromorphic functions; Riemann's mapping theorem. Prerequisite: Math. 421.

511. Linear Algebra (3) Vector spaces and linear transformations, canonical representations, elementary divisors and invariant factors. Prerequisite: Math. 481 or 537.

515. Partial Differential Equations of Mathematical Physics (3) Methods of solution of selected elliptic, parabolic, and hyperbolic partial differential equations, with reference to physical application. Prerequisite: Math. 421.

517-518. (Stat. 517-518) Probability Theory (3 each) Measure theoretic foundation of probability, distribution functions and laws, types of convergence, central limit problem, conditional probability, special topics. Prerequisites: Math. 452, 501.

520. Projective Geometry (3) General study of the subject from the synthetic and analytic standpoint. Prerequisites: Math. 472, 480.

523. Metric Differential Geometry (3) The usual classical treatment of the subject. Prerequisite: Math. 63.

524. Advanced Complex Analysis (3) Topics include boundary behavior of analytic functions, bounded analytic functions, conformal mapping, theory of Riemann surfaces. Prerequisite: Math. 509.

525. Theory of Functions of Several Complex Variables (3-6) Topics include fundamental properties of holomorphic functions, complex analytic manifolds, integral representations, Cousin problems. Prerequisite: Math. 509.

529-530-531. Topology (2 each) Topological, product, compact, metric, and connected spaces; continuous functions; separation axioms, countability conditions, combinatory topology.

532. Theory of Sets (3) Formal development of set theory on a logical basis and related methodological problems; applications to the foundations of mathematics. Prerequisite: Math. 428.

535-536-537. Algebra (2 each) Basic theory of semigroups and groups, rings and modules, fields, lattices. Prerequisites: Math. 480 (535) and 481 (536).

538. Commutative Algebra (3) Topics selected from noetherian rings and modules, primary decompositions, Dedekind domains and ideal theory, other special types of commutative rings or fields. Prerequisite: Math. 536.

539. Rings (3) Selected topics from the theory of rings. Prerequisite: Math. 536.

540. Valuation Theory (3) Selected topics from the theory of valuations on a field including completeness, extensions, ramification, local and global fields, adeles and ideles.

542-543. (Stat. 542-543) Statistical Distribution Theory (3 each) Random variables and expectations; discrete, continuous, univariate, multivariate, exact, and asymptotic distribution theory. Prerequisites: Math. 421 and 441 or 481.

544-545-546. General Topology (2 each) Topics selected including uniform spaces, function spaces, and proximity spaces. Prerequisite: Math. 531.

547-548-549. Lie Theory (2 each) Topics selected from theory of topological semigroups, topological groups, lie groups, transformation groups. Prerequisite: Math. 531.

550. (Phil. 550) Foundations of Mathematical Logic (3) The nature of logical basis of mathematics; critical examination and development of the basic parts of logical calculus. Prerequisite: Math. 480 or 428.

552. (Cmp.Sc. 552) Numerical Analysis I (3) Interpolation; remainder theory; approximation of functions; error analysis; orthogonal polynomials; approximation of linear functionals; functional analysis applied to numerical analysis. Prerequisites: Math. 420, 453.

553. (Cmp.Sc. 553) Numerical Analysis II (3) Eigenvalue and eigenvector determination; numerical solution of integral equations and ordinary differential equations with error and stability analysis. Prerequisites: Math. 420; Math. 454 or 481.

554. (Phil. 554) Logic and Metamathematics I (3) Completeness, Löwenheim-Skolem, Herbrand, and compactness theorems; first-order theories; categoricity, elimination of descriptions; decidability; algebraic and geometric applications. Prerequisite: Math. 428.

556. (Phil. 556) Recursion Theory (3) Recursive functions; normal form, enumeration and separation theorems; partial recursive functions; recursion theorems; special recursive functions; alternate formulations; related topics. Prerequisite: Math. 428.

557. (Phil. 557) Logic and Metamathematics II (3) Arithmetization; Gödel and Tarski incompleteness theorems; undecidability results; Gentzen-type systems and consistency results. Prerequisite: Math. 428.

558-559. (Stat. 558-559) Theory of Stochastic Processes (3 each) Stationary, independent, and orthogonal processes; discrete and continuous Markov processes; martingales and semi-martingales applications. Prerequisite: Math. 518.

560-561. Theory of Differential Equations (3 each) Topics selected from existence and uniqueness of solutions of differential systems, Sturm-Liouville systems, eigenvalue problems, integral operator solution. Prerequisites: Math. 72 or 83 or 100, and 508.

562. Theory of Special Functions (3) Topics include asymptotic expansions; Riemann-Papperitz and Trusdell's F equations; orthogonal polynomials; generating, beta, zeta, hypergeometric, Bessel, Legendre, elliptic functions. Prerequisites: Math. 72 or 83 or 100 and either Math. 420 and Math. 452 or Math. 508.

563. (Cmp.Sc. 563) Approximation Theory (3) Approximation in normed spaces; existence, uniqueness, characterization, computation of best approximations;

error bounds; degree of approximation; approximation of linear functionals. Prerequisites: Math. 453, 501.

564. (Cmp.Sc. 564) Numerical Solution of Partial Differential Equations (3) Numerical solution of initial and boundary-value problems; eigenvalues and eigenfunctions; errors, stability, and convergence. Prerequisite: Math. 552.

565. Functional Analysis (3) Theory of Banach and Hilbert spaces, including functionals and operators, and related topics. Prerequisite: Math. 502.

570. Special Topics in Geometry (3-12)

571. Special Topics in Analysis (3-12)

572. Special Topics in Algebra (3-12)

573. Special Topics in Applied Mathematics (3-12)

574. Special Topics in Foundations of Mathematics (3-12)

575-576. Mathematics Seminar (1-6 each) Selected topics from recent mathematical developments.

577. (Stat. 577) Special Topics in Probability (3-12) Special topics in probability which are not offered regularly but which are of special interest to faculty and students.

578. Special Topics in Topology (3-12)

579. (Cmp.Sc. 579) Special Topics in Numerical Analysis (2-12)

580. Special Topics in Number Theory (2-12)

581-582. Group Theory I, II (3 each) Selected topics from group theory including Abelian, solvable, nilpotent, and free groups, Sylow theorems, and group extensions and representations. Prerequisite: Math. 535.

583. Homological Algebra (3) Modules, diagrams, functors, homology of complexes, resolutions, cohomology of groups, tensor and torsion products. Prerequisite: Math. 536.

584-585-586. Algebraic Topology (2 each) Development of singular and Cech homology and cohomology theories; homotopy and cohomotopy theories. Prerequisite: Math. 531.

587-588-589. Point Set Topology (2 each) Topics selected from point set topology including upper semicontinuous and continuous decompositions, theory of continua, dimension theory. Prerequisite: Math. 531.

591. (Stat. 591) Seminar in Probability Theory (1-6) Lectures on current and recent research in various special topics in probability theory.

592-593-594. Number Theory (3 each) Congruences, quadratic residues, arithmetical functions, Dirichlet's theorem, prime number theorem, classical multiplicative ideal theory, partitions, valuations and p-adic numbers, divisors. Prerequisite: Math. 480. Prerequisite or concurrent: Math. 508.

Note: *Courses in Applied Mathematics, Computer Science, and Statistics are listed separately.*

MATHEMATICS (MATH)

H. E. Weber
In Charge of Graduate Programs in Mathematics
King of Prussia Graduate Center
King of Prussia, Pennsylvania 19406

Degree Conferred: M.Ed.

Graduate Faculty, Associate Members: Associate Professors Callahan and Duncan.

The program is offered specifically to permit teachers in the area to pursue advanced studies through evening classes while employed in teaching. Courses offered for the program are established and controlled by the resident departments at the University Park Campus.

Credit requirements may be satisfied by completing a minimum of 18 credits in approved mathematics courses, a minimum of 6 credits in approved mathematics and science courses, and a minimum of 6 credits in approved education courses. In addition, a term paper is required. All requirements must be met within six years or seven consecutive summers.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. An applicant must have a bachelor's degree and have completed 27 credits in mathematics including at least 15 credits at the intermediate level beyond calculus. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Further details concerning this program may be obtained by writing directly to the Graduate Center.

MECHANICAL ENGINEERING (M E)

Richard G. Cunningham, *Head of the Department*
207 Mechanical Engineering Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty, Senior Members: Professors Brickman, Cunningham, DiIlio, McLaughlin, Meyer, Moroz, Olson, Reethof, Schmidt, and Shearer; Associate Professors Brighton, Faeth, Heinsohn, Jonsson, and Lestz.

Graduate Faculty, Associate Members: Associate Professors DeCarolis, Park, Parke, Wolgemuth, and Zimmerman; Assistant Professors Bowlus, Healey, and Wambold.

Graduate programs and research facilities are available in thermodynamics and combustion, heat transfer, fluid mechanics, dynamic system analysis, mechanical design, biomedical engineering, automatic controls, and fluid amplifiers. Air pollution control, automotive safety, designing for noise control and for reliability also provide many research and design opportunities.

The language and communications requirement for the Ph.D. degree may be satisfied by an in-depth study of one foreign language (9-12 credits) or by taking three or more courses (minimum of 9 credits) of a nontechnical nature in a single area of study appropriate and related to the student's career orientation.

MECHANICAL ENGINEERING

The entering student must hold a bachelor's degree in engineering or physical science. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

MECHANICAL ENGINEERING (M E)

401. Mechanical Engineering (3-12)
402. Air Conditioning and Life Support Systems (3)
403. Rocket Propulsion (3)
405. Small Particle Technology (3)
409. Gas Turbines (3)
410. Power Plants (3)
411. Refrigeration (3)
412. Heat Transfer (3)
413. Internal Combustion Engines (3)
417. Theory of Engineering Instruments (3)
418. Principles of Turbomachinery (3)
421. (Aersp. 421) Intermediate Viscous Flow (3)
450. Design of Machine Tools (3)
451. Advanced Machine Design Problems (3)
452. Design Analysis (3)
453. Bearing Design and Lubrication (3)
455. Automatic Control Systems (3)
457. Advanced Mechanisms (3)
458. Noise Control in Machinery (3)
460. Reliability Concepts in Design (3)
470. Introduction to Air Pollution Control (3)
472. Engineering and Administration of Air Pollution Control (8)

503. Thermodynamic Process Analysis (3) Development of equations governing separate processes in complete machines to give basic system parameters and characteristics; transient processes; irreversible effects.

504. Advanced Engineering Thermodynamics (3-6) Pure and applied thermodynamics including its application to advanced engineering problems; collateral reading and discussion of the classical works on the subject. Prerequisite: M.E. 42.

506. Selected Topics in Mechanical Engineering (1-12) Advanced courses adapted to the individual requirements of graduates in mechanical engineering.

512. Heat Transfer—Conduction (3) One- and two-dimensional conduction heat transfer for steady state and transient systems with varying boundary conditions.

513. Heat Transfer—Convection (3) Laminar and turbulent flow heat transfer in natural and forced convection systems.

514. Heat Transfer—Radiation (3) Thermal radiation fundamentals; specular and diffuse systems; differential and integral methods; numerical techniques; industrial applications.

519. Compressible Fluid Flow (2-4) Two-dimensional subsonic flow; similarity rules; theory of characteristics; supersonic and hypersonic flows; nonsteady flow; oblique shock waves.

521. Electromagnetic and Thermodynamic Flow Systems (3) Thermodynamic equations for flow of reacting and nonreacting fluids in electromagnetic fields; applications to engineering problems.

522. Boundary Layer and Separated Flows (3) Behavior of viscous fluids, with emphasis on boundary layer and separation effects in internal flow.

540. Simulation of Mechanical Engineering Phenomena (3) Analog and numerical methods for simulation of problems in thermodynamics, heat transfer, fluid mechanics, diffusion, and machine dynamics.

550. Analysis of Design Problems (3) Case problems in machine design requiring integrated application of engineering knowledge.

552. Advanced Dynamics of Machines (3-6) Linear and torsional vibrations in and balancing of rotating and reciprocating machinery; exact analysis of stresses produced by these and other dynamic forces in machine parts. Prerequisites: E.Mch. 12, M.E. 54.

553. Friction and Lubrication (3) Sliding and rolling surface phenomena; hydrostatic, hydrodynamic, and magnetohydrodynamic lubrication theory; design and control of gas and fluid lubricated bearings.

555. Automatic Control Systems (3) Advanced problems and techniques in the design of automatic control systems with emphasis on stability, controller design, and optimum performance. Prerequisite: M.E. 455.

556. Advances in Control Systems Analyses (3) Control system theory and applications of newly developed theory to engineering systems; nonlinear systems, distributed systems, state-space methods. Prerequisite: M.E. 555.

557. Mechanism Synthesis (3) Geometrical and algebraic methods for synthesizing planar and spatial mechanisms, dynamics of spatial mechanism.

558. Fluid Control Systems (3) Systems elements, simplified models, analysis of interacting elements, instrumentation; computer-aided case study, and experimental investigations. Prerequisite: M.E. 455.

560. Probabilistic Methods in Machine Design (3) Reliability determination of machines for various types of interfering stress and strength probability functions. Probabilistic life consumed modeling. Prerequisites: Math. 409 or M.E. 460 or I.E. 323, M.E. 42, 54.

571. Air Pollution Seminars (1-2) Weekly seminars featuring the contributions of many different disciplines to the solution of air pollution and other environmental problems.

580. Investigation Projects (2-6) Special experimental studies or investigations in mechanical engineering, adapted to individual requirements.

MEDICAL TECHNOLOGY (MED T)

E. H. Cota-Robles
In Charge of Graduate Program in Medical Technology
S-101 Frear Building

Degree Conferred: M.S.

Graduate Faculty, Senior Members: Professors Anthony, Grun, Ludwig, O'Mara, Pazur, Stone, and Zimmerman; Associate Professors Hayes, McCarl, and Wickersham.
Graduate Faculty, Associate Member: Associate Professor Pootjes.

This is an interdisciplinary program designed for the registered medical technologist to obtain further academic training and some research experience. Students should expect to spend approximately one year (3 terms) at the University Park Campus taking course work and a second year at a cooperating hospital school doing a research problem for the master's thesis. Opportunities are available for course work and research in biology, biochemistry, clinical chemistry, immunology, microbiology, physiology, and virology. Research at the hospital school is under the joint supervision of a clinical scientist at the hospital and a University staff member.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. In addition to the bachelor's degree, candidates should be registered Medical Technologists (ASCP) and have had at least one year of laboratory experience following registration. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

For courses offered see majors in Biochemistry, Biology, Biophysics, Chemistry, and Microbiology.

METALLURGY (METAL)

William R. Bitler
In Charge of Graduate Programs in Metallurgy
221 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Bitler, Lindsay, and Muan. Associate Professors Healy, Hoke, Inman, Ryba, and Simkovich.

This program is one of the options in which a graduate student in the Department of Material Sciences can receive an advanced degree. A student may specialize, through both course work and research, in the science and engineering aspects of chemical, physical, or mechanical metallurgy.

The language and communications requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language together with courses from other designated areas.

Suitable preparation for graduate study in this program may be found in one of the material sciences such as ceramic science, fuel science, metallurgy, or solid state science; in engineering fields such as chemical or mechanical engineering; in basic physical sciences such as chemistry or physics; or in earth sciences such as geochemistry and mineralogy. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified

applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

METALLURGY (METAL)

401. Metallurgical Processes and Kinetics (3)
402. Electrometallurgy, Hydrometallurgy, and Corrosion (3)
404. Pyrometallurgy (3)
405-406. Metallography (3 each)
407. Metallurgical Engineering I (3)
408. Metallurgical Engineering II (3)
410. Metallurgical Investigations II (3)
412. Solid-State Metallurgy (3)
420. Particulate Systems in Mineral Processing (3)
421. Particle Technology Laboratory (1-3)
423. Recent Developments in Mineral Processing (3)
424. (Min.E. 424) Coal Preparation (3)
425. Interfacial Phenomena and Flotation (3)
459. Metallurgical Applications for Engineers (3)
460. Pollution Control in the Mineral Process Industries (3)

501. Metallurgical Problems (1-6 per term) Independent study of special problems in metallurgy.

502. Seminar in Metallurgy (1-6) Conferences, reading, reports, and special lectures.

508. Kinetics of Phase Transformations (3) Application of statistical mechanics and absolute rate theory to kinetics of phase transformations, including diffusion, nucleation, and growth rates. *Mr. Bitler*

509. Introductory Theoretical Physical Metallurgy (3) Quantum mechanics and its application to solid-state theory; introduction of Schroedinger's equation, its solutions, free-electron model, band model. *Mr. Bitler*

510. Magnetic and Transport Properties of Matebials (3) Treatment of the magnetic and transport properties of solids by quantum mechanics with applications to practical alloy development. Prerequisite: Metal. 509. *Mr. Bitler*

511. Advanced Physical Metallurgy (3) Physical metallurgy of an advanced nature; consideration of solid state bonding, crystal structure, alloy constitution. Prerequisite: Metal. 509. *Mr. Ryba*

513. Advanced Chemical Metallurgy I (3) Application of thermodynamics and kinetics to the heterogeneous metallurgical processes of oxidation, reduction, smelting, and refining. Prerequisites: Chem. 452, Metal. 301, 402, 404. *Mr. Healy*

514. Dislocation Theory (3) Self and interaction energies of dislocations and other defect structures; dislocation motions and their relation to mechanical properties. *Mr. Bitler*

515. Corrosion of Metals (3) Phenomena and theories of metallic corrosion; principles of alloy selection for engineering and structural uses in corrosive environments.

516. Flow and Fracture of Solids (3) Phenomenological and theoretical treatment of flow and fracture in solids. Prerequisites: Metal. 511, 514. *Mr. Hoke*

518. Heterogeneous Equilibria at High Temperatures (2-3) Treatment of

high-temperature equilibria in metal and oxide systems involving crystalline, liquid, and gas phases. Prerequisite: Metal. 513. *Mr. Muan*

519. Advanced Chemical Metallurgy II (3) Application of thermodynamics and kinetics to precipitation of nonmetallic and metallic phases from liquid and solid metals at elevated temperatures. Prerequisite: Metal. 513. *Mr. Healy*

520. Foundry Metallurgy (3) Physical-chemical considerations of the liquid state, solidification, and the solid state as applied to casting of metals and alloys. Prerequisites: Metal. 511, 513. *Mr. Lindsay*

522. Solid-Phase Reactions in Metals (3) Mechanisms and rate determining factors in solid-phase reactions in metals; diffusion processes, nucleation theory, precipitations from solid solution, eutectoid decomposition and order-disorder phenomena. Prerequisites: Metal. 508, 511. *Mr. Bitler*

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in metallurgical studies are listed under Materials Science.*

METEOROLOGY (METEO)

Alfred K. Blackadar, *Head of the Department*
503 Deike Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Blackadar, Hosler, and Panofsky; Associate Professor Dutton.

Graduate Faculty, Associate Members: Associate Professor Lavoie, Mr. J. Pena and Mrs. R. Pena.

Candidates may specialize in the study of problems in either theoretical or applied meteorology including such areas as cloud physics, various phases of dynamic meteorology including turbulence and atmospheric circulation, numerical modeling, macro- and microclimatology, synoptic meteorology, or meteorological instrumentation. The department also encourages interdisciplinary studies in such fields as agricultural meteorology, biometeorology, water resources, air pollution, and fluid mechanics.

The language and communications requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language (French, German, or Russian).

Requirements for admission include mathematics through differential equations and one year of college physics. Undergraduate study of meteorology is not required for admission. Special programs are available to encourage the graduate study of meteorology by all students with strong backgrounds in mathematics, physics, or engineering. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

METEOROLOGY (METEO)

400. Meteorology for Teachers (3)
401. Physical Climatology for Teachers (3)
402. Biometeorology for Teachers (2)
403. Science Projects in Meteorology (1)

404. Physics of Weather Forecasting (3)
411. Introduction to Synoptic Meteorology (3)
418. Introductory Physics of the Upper Atmosphere (3)
420. Tropical Meteorology (3)
430. Introduction to Synoptic Meteorology Laboratory (3)
431. Synoptic Meteorology Laboratory I (3)
432. Synoptic Meteorology Laboratory II (2-10)
433. Advanced Synoptic Analytical Techniques (3)
434. Application of Meteorological Satellite Data to Analysis and Forecasting (3)
443. Physical Meteorology (3)
445. Hydrology for Meteorologists (3)
450. Applications of Statistics to Meteorology (3)
451. Introduction to Dynamic Meteorology (3)
452. Hydrodynamics of the Atmosphere (3)
453. Atmospheric Thermodynamics (3)
461. Theory of Meteorological Instruments (3)
472. Physical and Dynamic Climatology (3)
473. Introduction to Micrometeorology (3)

500. Meteorological Seminar (1-3) Discussion of meteorological reports and papers; scientific outlook. Prerequisites: Meteo. 411, 451.

502. Selected Topics of Advanced Meteorology (1-3 per term) Current problems in meteorology. Prerequisite: a minimum of 15 credits in meteorology.

503. Atmospheric Turbulence (3) Atmospheric diffusion, heat conduction, friction, and evaporation; statistical properties of turbulence.

505. Bioclimatology (2) Climatic phenomena in their relation to life. Prerequisite: Meteo. 472.

506. Advanced Meteorological Analysis (2-6) Physical analysis of atmospheric phenomena; synoptic analysis of weather phenomena for advanced students.

507. Dynamic Oceanography (2) Physical properties of sea water; heat balance of the oceans; theory and observations of ocean currents, waves, and tides.

508. Physics of the Upper Atmosphere (2) Temperature distribution, composition, and electrical characteristics of the upper atmosphere; theories of aurora and light of the night sky.

509. Theoretical Climatology (2) Theory of latitudinal, annual, and diurnal temperature changes; theories of climatic changes, microclimate.

510. Cloud Physics (2) Current theories on phase changes in clouds and mechanisms responsible for precipitation; techniques of cloud modification and control.

511. Cloud Dynamics (2) Study of the structure of cloud-scale motions; numerical models of cumulus clouds; thunderstorms, hailstorms, tornadoes, mesoscale organization of convection. Prerequisite: Meteo. 453.

520. Indirect Atmospheric Probing (3) Analysis and description of measurements made with radar and bistatic radio, optical and acoustic systems used for indirect atmospheric sounding. Prerequisite: Meteo. 443.

545. Snow Hydrology (2) Importance of snow in meteorology and the hydrologic cycle; snow properties, metamorphism, prediction of snowmelt runoff, and snow management potentials.

550. Atmospheric Motions (3) Fundamental properties and conservation requirements of the hydrodynamic equations; elements of advanced dynamic meteorology and applications to atmospheric dynamics. Prerequisite or concurrent: A.M. 451.

551. Atmospheric Wave Motion (2) From classical and physical hydrodynamics to the numerical prediction of wave motion in a baroclinic atmosphere. Prerequisite: Meteo. 452.

552. Advanced Atmospheric Dynamics (2) Numerical prediction models, general circulation, thermal and gravitational tides in a spherical shell, and empirical orthogonal functions of statistical forecasting. Prerequisite: Meteo. 551.

553. Energetics of Atmospheric Motion (2) Theoretical investigation of the conversions of energy in the atmosphere; maintenance of the general circulation. Prerequisite: Meteo. 452.

555. Atmospheric Diffusion (2-3) Dispersion of atmospheric contaminants; experiments, theory and practical implications for air pollution problems. Prerequisite: 3 credits of statistics.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in meteorological studies are listed under Materials Science.*

MICROBIOLOGY (MICRB)

E. H. Cota-Robles, *Head of the Department*
S-101 Frear Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Casida, Cota-Robles, Lindstrom, Ludwig, Stone, and Zimmerman; Associate Professor Ceglowski.

Graduate Faculty, Associate Members: Associate Professors Pootjes, Tershak, and Zarkower; Assistant Professors Claus, Doty, and Fung.

Specialized areas of study in microbiology include: cytology, ecology, food, genetics, immunology, physiology, and virology (both animal and bacterial), and environmental and industrial microbiology. There is opportunity for cooperative research with other departments.

The language and communications requirement for the Ph.D. may be satisfied by intermediate knowledge of one foreign language (French, German, or Russian).

Prerequisites for admission are 16 credits in inorganic and organic chemistry, 6 in physics, 8 in microbiology, and mathematics through calculus. Admission may be granted with deficiencies up to 8 credits, to be made up while pursuing graduate work. Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests. A satisfactory score on the Graduate Record Examination is required.

MICROBIOLOGY (MICRB)

400. Introductory Environmental Microbiology (3)
401. General Microbiology (4)

407. Problems in Microbiology (1-12)
410. Immunology and Serology (3)
411. Survey of Microbiology (1 per term)
413. Soil Microbiology (3)
414. Food Microbiology (4)
415. Introduction to Animal Viruses (2-4)
416. Industrial Microbiology (4)
417. Epidemiology (2)
418. Bacterial Viruses (4)

507. Seminar (1 per term) Reports on current fields of research.

508. Bacterial Physiology (2-4) Contributions of environment, finestructure, and metabolism to the functioning cell. Prerequisite: Bioch. 402.

511. Special Topics in Microbiology (1-6)

512. Bacteriological Techniques (1-6) Practice in special laboratory techniques including manometry, tissue culture, and serology.

516. Bacterial Genetics (2-4) Mechanisms of variation in microorganisms including mutation, adaptation, sexual recombination, transduction, and transforming factors. Prerequisite: 3 credits each in microbiology and genetics.

520. Biochemical Virology (2) Role of enzymes and nucleic acids in virus synthesis. Regulation of virus reproduction in animal and bacterial cells. Prerequisite: Bioch. 402.

529. (C.E. 579) Aquatic Microbiology (3) Ecology and physiology of microorganisms of inland waters, estuaries, and oceans; microbiology of wastewater treatment. Prerequisite: introductory microbiology.

MICROBIOLOGY (MICRB)

Fred Rapp, *Chairman of the Department*
The Milton S. Hershey Medical Center

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Member: Professor Rapp.
Graduate Faculty, Associate Members: Assistant Professors Barnes, Duff, Funk, Glaser, and Lausch.

The graduate program is oriented to the study of any aspect of microbiology, especially the general areas of bacteriology, virology, immunology, genetics, and viral oncology. Subdivisions of these disciplines are also available, and many problems in these areas are under investigation by members of the faculty.

The language and communications requirement may be satisfied by one foreign language such as French, German, or Russian. Courses in creative writing or humanities can be substituted with permission.

Qualified students with undergraduate preparation in either the biological, biochemical, or physical sciences may apply. A reasonable background in biology, chemistry, and mathematics is required, although it will be possible to strengthen the background in any of these areas during the first year in the graduate program. Programs leading to advanced degrees will be tailored to the background and individual needs of the candidates.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Two letters of recommendation are required and a personal interview is desirable.

This program is offered only at The Milton S. Hershey Medical Center.

MICROBIOLOGY (MICRB)

551. Medical Microbiology (3) Principles of microbiology; viruses, rickettsia, bacteria, and fungi as agents of disease. Introduction of microbial genetics, epidemiology, and immune mechanisms.

552. Medical Microbiology Laboratory (2) Laboratory exercises to augment Micrb. 551. Laboratory tests used to characterize microorganisms and to aid in diagnosis of disease.

553. Science of Virology (3) Replication of viruses and effect on host, including transfer of genetic information, immunology, and oncogenic properties of viruses.

554. Immunology of Infection (3) The nature of antigens and antibodies, humoral and cellular immune response governing histocompatability, transplantation, tolerance, and auto-immune disease.

555. Microbial Physiology and Metabolism (3) Physiology and comparative biochemistry of microorganisms, especially human pathogens. Concepts of genetic regulation and balanced growth applied to cell replication.

556. Microbial Genetics (3) Genetics of microorganisms, including gene mapping, lysogeny, information transfer, and viral carcinogenesis.

570. Topics in Microbiology (2 per term) Lectures and seminars concerning current developments in microbiology.

571. Seminar in Microbiology (1 per term) Weekly presentations by faculty and postdoctoral and predoctoral trainees of current work in the department.

572. Literature Reports (1 per term) Weekly analysis of current literature in microbiology.

573. Selected Readings (2 per term, maximum of 6) Supervised reading program of pertinent literature in microbiology and related scientific fields.

580. Laboratory Experiments in Microbiology (2-6 per term) Laboratory exercises in microbiology, including cell culture, microscopy, radioisotope and other biochemical procedures, serology, and genetic techniques.

581. Special Projects in Microbiology (2-6 per term) Research projects carried out by graduate students under supervision of a member of the faculty.

MINERAL ECONOMICS (MN EC)

JOHN D. RIDGE, *Head of the Department*
104 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Gordon and Ridge; Associate Professors Harris, Newcomb, and Schenck.

The program in mineral economics prepares students for careers in mineral industries management, administration, or economic analysis and planning. Students may specialize in such areas as commodity analysis (fuels, metals, or nonmetals); resource economics (mineral policy or area studies); industrial economics (administration, market research, or financial matters); geostatistical and economic analysis of exploration and exploitation problems; or operations research and statistics (resource allocation, forecasting, or decision making).

Two related but distinctly different general programs for obtaining the M.S. and Ph.D. degrees are available, the one chosen depending on the education and practical experience of the candidate. One program is for students whose background is in the mineral industries and who wish to combine their scientific training with an understanding in depth of the methods by which economics can aid in solving problems in mineral industries exploration, exploitation, and processing. Requirements for admission to this program are 24 credits in chemistry, physics, mathematics, or statistics; 12 in the earth sciences; 9 in economics, mineral economics, commerce, business administration, or industrial management; and 6 in engineering subjects.

The second program is for students whose background is in economics and whose training and experience have given them an interest in applying their economic skills to the solution of mineral industries problems. Requirements for admission to this program are 12 credits in economics, mineral economics, and business administration; 6 in geological sciences; and 9 in mathematics and statistics.

The differences between the programs followed by these two groups of students will affect every aspect of their graduate programs—thesis work, required mineral economics courses, and elective selection. In all cases, the choices among courses and the emphasis within courses taken would be determined by the background of the student, the mineral industries-based program placing equal weight on the technical and economic aspects of mineral economics and the economics-based program placing more weight on the economic than on the technical features of the problems considered.

In addition to the normal degree requirements of the Graduate School, candidates for the M.S. degree must write a thesis and defend it orally. Doctoral candidates in the mineral industries-based program must complete at least 15 credits in economics (including courses used for admission). Doctoral candidates in the economics-based program must complete at least 12 credits in the earth sciences or mineral engineering. The candidacy examination for the doctorate is entirely written, with the exception that the oral examination for the M.S. degree at The Pennsylvania State University may be used as the candidacy examination for the doctorate. If this is done, the M.S. examination will be more detailed and broader in scope than it would be for the M.S. alone. The comprehensive examination for the doctorate includes written examinations in the major and minor fields in addition to the oral examination required by the Graduate School. The language and communications requirement for the Ph.D. degree may be satisfied by competence (as defined by departmental rules) in one foreign language or mathematical statistics.

Students with deficiencies of 9 credits or fewer in either program may be admitted as degree candidates but will be required to make up such deficiencies without these credits being applicable toward the advanced degree. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for ad-

mission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

MINERAL ECONOMICS (MN EC)

400. Seminar (1)
453. Nonmetallic Minerals (3)
483. Economics of the Metals Industries (3)
484. Economics of Energy Resources (3)
486. The Energy Market (3)
490. Mineral Valuation (3)
491. Analysis of Mineral Data (3)

500. Advanced Readings in Mineral Economics (3) Selected readings on topics in mineral history, mineral economics research, applications of economic theory, mineral policy and law, and mineral exploration.

504. Advanced Principles of Mineral Economics (3) Minerals as capital—taxation, conservation, and land tenure; operations of mineral markets; government policy; minerals in world trade and development.

506. Advanced Studies in Mineral Commodities (3) Economic studies of selected mineral commodities and their products. Prerequisite: Mn.Ec. 491.

513. Appraisal of Mineral Resources and Analysis of Exploration Decisions (3) Mineral resource concepts; various quantitative methods for resource evaluation, including computer simulation; exploration economics and decision making within quantitative frameworks. Prerequisites: Mn.Ec. 490, 491.

522. Technologic Influences (3-9) Relationship of technologic advancements to economic development of the mineral industries. Prerequisite: 3 credits in Mn.Ec. 500.

525. Problems in Mineral Economics (3-12) Individual research involving library, laboratory, or field work to develop solutions to selected techno-economic problems of the mineral industries. Prerequisite: Mn.Ec. 500.

590. Mineral Economics Seminar (1 per term) Preparation and presentation of papers on advanced problems. Required each term in residence.

MINERAL ENGINEERING MANAGEMENT (M E M)

Thomas V. Falkie
Chairman of the Committee on Mineral Engineering Management
118 Mineral Industries Building

Degree Conferred: M.Eng.

Graduate Faculty, Senior Members: Professors Aplan, Charmbury, Essenhigh, Given, Griffith, Hummel, Lindsay, E. Miller, Niebel, Ridge, Slobod, Stahl, Stefanko, and Williamson; Associate Professors Falkie, Farouq Ali, Harris, Healy, Lovell, and Schenck.

Graduate Faculty, Associate Members: Associate Professors Guild and Raphael, Assistant Professors Manula and Slater.

This program is designed to educate engineers for advancement into executive

production management positions in the mineral and heavy construction industries, in development and sales in manufacturing companies, and in consulting firms. Its aim is to provide the knowledge, skills, and attitudes needed by persons to become innovators and responsible decision-making leaders. Participants are trained to create new designs, systems, and methods, and to plan, develop, and lead mineral industry organizations.

The content of appropriate courses is based upon specific problems encountered in the mineral industries. Such courses are offered by the departments which have combined their resources to offer this interdisciplinary effort; namely, Departments of Mineral Engineering (Mining and Petroleum and Natural Gas Sections), Mineral Economics, Material Sciences, and Industrial Engineering. Courses in these areas and others may be selected by students and adapted to their individual interests.

The program emphasizes quantitative methods (statistics, operations research, and computer applications); principles of economics applied in mineral industries (mineral economics, mineral commodities, cost and investment analysis, economic feasibility and profitability analysis, analysis involving intangibles); and management (finance, marketing, industrial, labor relations, production, and operation management).

Students are required to present a scholarly written report on a suitable project the topic of which may be suggested by industry.

For admission a bachelor's degree in one of six engineering branches of mineral industry (mining, petroleum, mineral processing, metallurgy, fuel, and ceramics) or some other closely related field (industrial, civil, geological, mechanical, or chemical engineering) is required. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exception to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

MINERAL ENGINEERING MANAGEMENT (M E M)

510. Production and Operations Management (3-9) Overall planning, design, and selection of equipment; programming and scheduling of mineral operations; statistical control of costs and production indices.

MINERAL PROCESSING (MN PR)

Frank F. Aplan
In Charge of Graduate Programs in Mineral Processing
4 Mineral Sciences Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Aplan, Austin, and Sun.
Graduate Faculty, Associate Member: Assistant Professor Hogg.

This program is one of the options in which a graduate student in the Department of Material Sciences can receive an advanced degree. The process engineering of minerals involves treatment of raw materials to prepare them for conversion to useful products and is basic to such important industries as steel, coal, nonferrous metals, heavy chemicals, nonmetallic minerals, cement, etc. The mineral processing engineer is concerned with the separation of valuable materials from worthless rock by physical and chemical means as well as with the application of these methods to the recycle processing of used metals and minerals. He is also vitally interested in the control of air, land, and water pollution—particularly as it relates to mineral raw materials.

MINERAL PROCESSING

The training of a mineral processing engineer involves interdisciplinary combinations of chemistry, physics, the geological sciences, and engineering. This knowledge is then integrated with specialized knowledge—the creation, characterization, separation and agglomeration of particles; the surface chemistry of mineral particles; and chemical separations—to provide the basis for developing and understanding the practical means of separation of valuable material from that which is worthless.

Pollution control is an important aspect of mineral processing because of the problems of disposal of vast quantities of waste produced by the mining, metallurgical, cement, power, and heavy chemical industries; the enormous volume of process water used by these heavy industries; the use of mineral processing equipment and processes in most air and water pollution control methods; and the application of mineral processing methods to the recycle and reuse of metals and other valuable materials presently being discarded as trash. Specifically designed courses of study are available to allow the student to emphasize pollution control in his course work and thesis research.

The language and communication requirements for the Ph.D. degree may be satisfied by reading proficiency in one foreign language. Students whose first language is English will demonstrate proficiency in German, Russian, or Japanese (or other language in which a major body of relevant technical literature exists). Where practicable, the examination will be one given or recommended by the language department. Students whose first language is not English will be required to show fluency in reading, speaking, comprehending, and writing English and may be required to demonstrate proficiency in one other language (German, Russian, or Japanese). They will normally be expected to take Spch. 115 and pass it with a grade of B or A (unless the report of the Language Testing Center for International Students indicates that this is unnecessary) and, in addition, practice in writing and discussing papers in English will be required by the study panel until a satisfactory standard is obtained. A satisfactory seminar presentation is required.

Graduates with bachelor's degrees in ceramics, chemistry, chemical engineering, fuel science, the geological sciences, mathematics, metallurgy, mining, physics, or some branch of engineering are eligible for admission. Students with deficiencies may be required to make them up concurrently with their graduate studies. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

The following courses listed elsewhere are appropriate for Mineral Processing students: Mat.Sc. 411, 420; Metal. 401, 402, 404, 420, 421, 423, 424, 425, 460.

MINERAL PROCESSING (MN PR)

*400. Special Problems (1-9)

501. Interfacial Phenomena in Mineral Systems (3) Applications of surface phenomena to mineral engineering systems. Thermodynamics of surfaces, flotation, adsorption of detergents, electrical double layer, flocculation, dispersion. Prerequisite: Chem. 451. *Staff*

502. Froth Flotation and Agglomeration (3) Intensive study of theory and applications of froth flotation and agglomeration. Prerequisite: Mn.Pr. 501. *Staff*

504. Special Topics in Mineral Processing (1-6 per term) Research work and study on specific problems in mineral processing. *Staff*

505. Physical Separations in Mineral Processing (3) Intensive study of theory

* May be repeated for a total of 9 credits.

and applications of gravity, magnetic, electrostatic, centrifugal and other methods of mineral processing. Prerequisite: Metal. 420. *Staff*

506. Mineral Process Plant Design (3-10) Process design and economy. Development and quantification of flow sheets. Integration of unit operations. Plant layout, equipment selection and instrumentation. Prerequisite: Metal. 420. *Staff*

507. Chemical Methods in Mineral Processing (3) Practice and theory of methods to upgrade ores by chemical treatment including roasting, solubility separations, surface phenomena, and reactions. Prerequisite: Metal. 420. *Staff*

508. Mineral Particle Systems (3) Creation, characterization, separation and agglomeration of particles. Comminution, sizing, fractionation of powders; surface area, pore size determinations. Agglomeration and balling. *Staff*

509. Particle-Fluid Dynamics (3) Movement of particles in fluids, rheology of non-Newtonian mineral suspensions, design of concentrating devices, fluidized beds, electrodynamic, magnetic separations. *Staff*

MINERALOGY AND PETROLOGY (MIN P)

Arthur L. Boettcher
In Charge of Graduate Programs in Minerology and Petrology
211 Deike Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Barnes, Bates, Brindley, Burnham, Greig, Griffiths, Keith, Muan, Newnham, Roy, Thornton, Wickman, and Wright; Associate Professors Boettcher, Dachille, Rose, Smith, and White.

Graduate Faculty, Associate Members: Associate Professor Suhr, Assistant Professors Deines and Langmuir.

Areas of specialization include igneous, sedimentary, and metamorphic petrology, experimental petrology, mineralogy, crystallography, crystal chemistry, X-ray mineralogy, clay mineralogy, ore mineralogy, and application of statistics in the earth sciences.

The language and communications requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages or by comprehensive knowledge of one.

The general requirements for admission are mathematics through integral calculus; chemistry through quantitative analysis; 10 credits in general physics; and 30 credits in geology, petrology, and mineralogy including microscopical petrography. Additional specific requirements must be fulfilled in most areas of specialization.

Students who have taken somewhat less than the indicated minimum of subjects may be admitted but must make up their deficiencies concurrently with their graduate studies. Students with a 2.70 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.70 grade-point average may be made for students with special backgrounds, abilities, and interests.

The no-thesis option is available for the M.S. degree.

MINERALOGY (MIN)

400. (Cer.Sc. 400) Nonmetallic Crystal Chemistry (2)
402. Mineralogy and Petrology for Teachers (3) *Mr. Thornton*

411. (Mat.Sc. 411) Instrumental Techniques Applied to Materials and Mineral Science Problems (1-5)
Unit A. X-Ray Diffraction
Unit B. Electron Microscopy
Unit C. Spectroscopy — *Mr. Suhr*
Unit D. Electron Probe Analysis
Unit E. Scanning Electron Microscopy

421. (Mat.Sc. 421) X-ray Diffraction (3)

431. (Mat.Sc. 431) Instrumentation for Physical Measurement and Control (3)

450. Volcanology (3) — *Mr. Thornton*

463. Optical Mineralogy (3) — *Mr. Kerrick*

483. Petrology (3) — *Mr. Thornton*

484. Petrology (2) — *Messrs. Langmuir and Williams*

490. Petrographic Problems (1) — *Mr. Thornton*

500. Optical Crystallography of Materials (3) Optical methods, microscopic techniques, and measurement of optical constants of crystals; theory and application of the universal stage. Prerequisite: Min. 463. *Mr. Kerrick*

501. Petrology (3-6) Microscopic study of rocks, emphasizing classification and genetic relationships. *Mr. Thornton*

502. Mineralogical Problems (3) Original study of some limited mineralogical or petrological problems.

505. Mineralogy Seminar (1-2) Reading, presentation, and discussion of literature dealing with various phases of theoretical mineralogy. Topics are selected to meet the interests of the majority of the students.

*510. Metamorphic Petrology (2-6) Detailed review of chemical, mineralogical, and structural changes that take place during metamorphism. Prerequisites: Min. 483, 484. *Mr. Kerrick*

513. Scientific Method in Geoscience (3) Problem formulation, sampling designs, selection of variates, and comparison of techniques for analysis of aggregates. *Mr. Griffiths*

514. Statistical and Electronic Data Processing Procedures for Geoscience (3) Statistical analysis of experimental data using univariate and bivariate procedures.

515. Ore Microscopy (3) Optical and hardness measurements and phase equilibria as used in identification and interpretation of textures of ore minerals. *Mr. Barnes*

525. Igneous Petrology (2-6) Origin, distribution, and composition of igneous rocks. Prerequisites: Gchem. 513; Min. 483, 484, 500, 527. *Messrs. Burnham and Thornton*

526. Problem Solving in Geoscience (3) Multivariate statistical analysis, decision making, operations research, and systems analysis in geoscience. *Mr. Griffiths*

527. Mineralogy I—Silicates (3) Detailed study of the crystal structures and crystal chemistry of the silicate minerals.

528. Mineralogy II—Nonsilicates (3) Detailed study of the crystal structures and crystal chemistry of the nonsilicate minerals.

*Credits to be arranged, 2-4 per term.

530. (Cer.Sc. 530) Structure, Properties, and Occurrence of Clay Minerals (2-5) Structure analysis and identification of clay minerals; mineral transformations and behavior; occurrence, genesis, and petrography of fine-grained sediments. *Mr. Brindley*

531. (Mat.Sc. 531) Electron Transmission Microscopy in the Materials and Mineral Sciences (3) Discussion of electron image contrast theory as a tool for study of atomic substructures in the materials and mineral sciences.

532. (Mat.Sc. 532) Structure Analysis (2) Crystal structure determination methods: space groups, structure factors, heavy atoms and isomorphous replacement, Fourier synthesis, Patterson maps, inequalities, refinement techniques. Prerequisite: Mat.Sc. (Min.) 421.

533. (Mat.Sc. 533) Single Crystal Methods (2) Experimental techniques in crystal structure determination: crystal selection, space group determination, measurement of intensities, analysis of data. Prerequisite: Mat.Sc. 421 or Min. 421.

534. (Mat.Sc. 534) Diffraction by Crystals (2) Interaction of radiation with matter: coherent and incoherent scattering, extinction, fluorescent, polarization. Prerequisite: Min. (Mat.Sc.) 421.

535. (Mat.Sc. 535) Geometrical Crystallography (3) Derivation of lattices, types, point groups and space groups with applications.

538. (Mat.Sc. 538) Electron Beam Analysis of Solids via X-ray and Electron Emission (3) Theory of phenomena occurring in electron-bombarded solids and their applications to analysis of solids.

540. Meteoritics (2) Mineralogy, petrology, and chemistry of meteorites; theories of their origin and formation. Prerequisite: Min. 483 or 501.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in mineralogical studies are listed under Materials Science.*

MINING ENGINEERING (MNG E)

Thomas V. Falkie, *Head of the Department of Mineral Engineering*
118 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Charmbury, Hardy, and Stefanko; Associate Professors Falkie, Lovell, and Voight.

Graduate Faculty, Associate Member: Assistant Professor Manula.

Areas of specialization which may be followed in research and course work include mine property valuation and economics of mining engineering (ore estimation, cost analysis and control, budgeting); mechanization and mine plant (unit operations, materials handling, continuous mining, power supply); development and exploitation methods (mine planning and layout, design of systems); mine management, production engineering (work and methods analysis, operations analysis); operations research, environmental control (gas and dust technology, ventilation, air conditioning, hygiene, illumination, safety, mine drainage, land reclamation, waste disposal); and rock mechanics (stress analysis, roof and ground control, penetration, fragmentation, subsidence).

The language and communications requirement for the Ph.D. degree may be

satisfied by completion of courses in two languages or by completion of courses in one language and 6 credits of computer science.

A bachelor's degree in mining engineering or a related engineering field is required for admission. Students may be required to make up deficiences in their area of specialization. Certain basic, related courses outside the department may be approved as part of the major. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

MINING (MNG)

400. Mining and Our Environment (3)
402. Mine Plant Design (3)
410. Mining Engineering Analysis (3)
411. Mine Systems Engineering (3)
422. Mine Ventilation and Air Conditioning (3)
431. Rock Mechanics (3)
451. Advanced Mining Engineeering (1-3)

513. Mine Cost Analysis (3) Nature of mining costs, their analysis and control: depreciation and depletion, capital and operating costs, budgets, records.

514. Mine Operations Analysis (3) Application of operations research techniques in determining optimal design and operating policies for mine management. Prerequisite: Mng. 411.

515. Mine Systems Simulation (3) Principles and practices of probabilistic and deterministic simulation in the analysis of operating systems related to mills and mines. Prerequisites: Mng. 411, Cmp.Sc. 401.

531. Rheological and Strength Characteristics of Rocks (3) Properties of rocks and their determination; failure theories; brittle to ductile transition; rheological behavior. Prerequisite: Mng. 431.

532. Special Topics in Rock Mechanics (1-3) Behavior of rock under static loading; underground stress instrumentation; experimental stress analysis; design of mine openings; theories of subsidence.

533. Post-Yield Mechanics of Rock (3) Theory of inelastic, time-independent rock behavior; selected applications to drilling, blasting, mine opening, pit slopes, and ore passes. Prerequisite: Mng. 431.

541. Theory of Rock Penetration (3) Behavior of rock under dynamic loads intended to penetrate; basic energy relations; application of theory to drilling and other penetration. Prerequisites: E.Mch. 13, Mng. 30, Phys. 203.

542. Theory of Rock Fragmentation (3) Behavior of rock under dynamic loads intended to fragment; physical chemistry of explosives; detonation; theory of blasting; design of drill rounds. Prerequisites: E.Mch. 13, Mng. 30, Phys. 203.

543. Strata Control Engineering (3) Theoretical considerations; convergence, abutments, subsidence; rockbursts; underground support systems; design of mine openings. Prerequisite: Mng. 431.

545. Rock Mechanics Instrumentation (3) Strain gage circuitry, transducers, electro-hydraulic servo installations, and integrated strain and force measuring systems as applied to rock mechanics. Prerequisite: Mng. 431.

580. Mining Engineering Research (1-3 per term) Supervised research on a specific problem involved in mining science or technology.

590. Graduate Mining Seminar (1 per term) Preparation and presentation of formal papers on problems of an advanced nature in mining engineering. Required once during each year of residence.

MUSIC (MUSIC)

Robert W. Baisley, *Head of the Department*
232 Music Building

Degrees Conferred: M.A., M.F.A.

Graduate Faculty, Senior Member: Assistant Professor Brinsmaid.

Graduate Faculty, Associate Members: Professors Baisley and Wild, Assistant Professor Case.

The Master of Arts degree program is designed to provide a wide range of studies in music. The student may emphasize one of the following areas, or may elect a program including work in all of them: theory, performance, history, and composition. Admission requires completion of a recognized music major. A thesis or paper is optional to all M.A. candidates in the program.

The Master of Fine Arts degree program is planned to provide professional emphasis. Students will specialize in either performance or composition. In addition to credit requirements, admission to the program is contingent upon department certification of the candidate's competence. According to the area of specialization, auditions or submission of manuscripts are required. Arrangements for this can be made by the student with the department. While 48 credits are listed as a minimum requirement, it should be noted that the amount of course work necessary may exceed the minimum according to the needs and background of the student involved.

Students who lack the recommended upper-class courses in music may be required to take additional course work without receiving graduate credit.

The department sponsors musical activities, and candidates for both degrees are required to participate in positions of responsibility.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

MUSIC (MUSIC)

410. Music of the Twentieth Century (3)
412. Music of the Baroque Period (3)
413. Music of the Middle Ages (3)
414. Music of the Renaissance (3)
417. Music of the Classical Period (3)
418. Music of the Romantic Period (3)
*‡429. Vocal Style (3) Fee $80.
433. The Singing Voice (3)
454. Harmonic Analysis (3)

* Course may be scheduled only by conference with the head of the department.
‡ May be repeated for a total of 18 credits.

455. Form and Analysis (3)
457. Composition (3)
459. Orchestration and Arranging (3)
466. Advanced Conducting (3)
467. Opera Workshop (1-6)
468. Advanced Chamber Music (1-6)

*‡501. Advanced Harpsichord (3) Instruction in harpsichord playing; preparation for recital performance. Fee $100.

*‡503. Advanced Orchestral Instruments (3) Study, repertoire building, and recital performance. Fee $80.

*‡511. Advanced Piano (3) Piano literature of all periods for public performance. Fee $80.

*‡520. Voice (3) Study, repertoire building, and recital performance. Fee $80.

*‡531. Advanced Organ (3) Study, repertoire building, and recital performance. Prerequisite: 4 credits of Music 31 and/or 38. Fee $100.

543. Modern Harmony (3) Harmonic writing based on twentieth century practices with attention to traditional idioms that serve as foundation.

545. Counterpoint (3) Principals of contrapuntal techniques from the sixteenth century to the present. Required of all M.F.A. candidates in composition.

*‡558. Free Composition (3) Composition: vocal and instrumental, standard or modern idioms.

571. Performance Practices (3) Analysis and performance of music of various periods based on manuscripts, documents, and other source materials.

580. Studies in Orchestral Literature (3) Selected studies in orchestral literature from the seventeenth century to the present.

581. Studies in Chamber Music Literature (3) Selected studies in chamber music of all types from the seventeenth century to the present.

582. Studies in Keyboard Literature (3) The literature of major keyboard instruments from the sixteenth century to the present.

583. Studies in Choral Literature (3) Selected studies in choral literature of all types from the Renaissance to the present.

584. Studies in Operatic Literature (3) Studies in the development of the opera from 1600 to the present treating both libretto and music.

590. Music Seminar (1-6) Seminar in the history, art, and science of music, with readings, discussion, and performance.

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* Course may be scheduled only by conference with the head of the department.
‡ May be repeated for a total of 18 credits.

MUSIC EDUCATION (MU ED)

FRANCES M. ANDREWS, *Head of the Department*
264 Chambers Building

Degrees Conferred: D.Ed., M.Ed.

Graduate Faculty, Senior Members: Professors Andrews and Dunlop, Associate Professor Deihl.

Graduate Faculty, Associate Members: Professor Campbell, Assistant Professor Boyle.

Graduate programs in music education prepare students for careers in public school music teaching, music supervision, college teaching, administration, or research. It is possible to include study in a number of these areas in the M.Ed. or D.Ed. programs.

Completion of a recognized music education major, or program leading to teaching certification in music, is a prerequisite for admission to the M.Ed. or D.Ed. programs.

Applicants for the master's program who present a 2.50 junior-senior average and two satisfactory professional references will be considered for admission to the Department of Music Education, provided they have appropriate course background and musical proficiency. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum grade-point average may be made for students with special backgrounds, abilities, and interests.

Admission to the doctoral program requires: A junior-senior minimum average of "B"; approximately half of any graduate credits of "A" quality; interview prior to admission; submission of satisfactory score on Miller Analogies Tests; five recommendations attesting to scholarship, musicianship, and ability to do independent study; and a minimum of two years successful teaching experience in public or private schools.

MUSIC EDUCATION (MU ED)

415. WORKSHOP IN SELECTED MUSIC EDUCATION STUDIES (1-6)
446. THE ELEMENTARY MUSIC SPECIALIST (3)
468. THE TEACHING OF PIANO (3)
469. BAND AND ORCHESTRA TECHNIQUE (3)
471. TEACHING MARCHING BAND (3)
472. WIND INSTRUMENT MATERIALS (3)
473. PSYCHOLOGICAL FOUNDATIONS OF MUSICAL BEHAVIOR (3)
474. TESTS AND MEASUREMENTS IN MUSIC (3)
480. CHORAL PROGRAM IN THE SECONDARY SCHOOL (3)
487. CHILDREN'S SONGS AND RECORDS (3)

500. MUSIC EDUCATION SEMINAR (3-6) Problems of various phases of music education, both instrumental and vocal; research and literature dealing with these problems.

501. PROBLEMS AND PROJECTS IN MUSIC EDUCATION (1-6) Independent work on special topics of music education pertinent to the development of curricula, methods, and materials in music education. Prerequisite: 12 graduate credits in education (including music education).

525. PROSEMINAR: GRADUATE STUDY IN MUSIC EDUCATION (1-3) Bibliography; location and evaluation of reference materials; organization, form, style in preparing music education research reports and other papers.

555. RESEARCH METHODS IN MUSIC EDUCATION (3-6) Research methods and de-

signs for problems in music education; techniques for studying cognitive, affective, and psychomotor responses to musical stimuli. Prerequisites: Mu.Ed. 525, Ed.Psy. 406 or 407, 475.

569. Present-Day Trends in Instrumental Music (3-6) New methods and materials for band, orchestra, and ensembles.

570. Choral Technique (3-6) Analysis and evaluation of choral materials appropriate for secondary school chorus; program building; practical rehearsal and conducting techniques. Prerequisite: 6 credits of vocal study.

572. Instrumental Pedagogy (3-6) Research problems in band and orchestra. Prerequisite: Mu.Ed. 54 or practical experience.

573. The Materials of Appreciation (3) Examination of written and recorded materials and appropriate techniques for developing appreciation of music, grades one through twelve.

574. Present-Day Trends in Music Education (3-6) Present-day music education materials and methods (elementary and secondary levels) in relation to modern educational philosophy; emphasis on practical problems presented by members of the class. Prerequisites: Mu.Ed. 48, teaching experience.

575. The Junior High School Music Curriculum (3) Instructional materials, procedures, curricular and extracurricular activities, integration with other subjects.

576. Music Supervision (3) Current educational procedures in training music supervisors.

581. Contemporary Music Education (3) Prerequisite: 20 credits at the graduate level including Mu.Ed. 500.

582. Theory and Projects in Musical Learning (3-6) Experimentation and self-instructional techniques involved in musical learning projects. Prerequisite: Inst.M. 435.

590. Internship in Music Performance Techniques (1-6) Internship in selected school or music performance situations other than those in the district where the graduate student is employed.

594. Pedagogy of Music Theory, Reading, and Ear Training (3) Instructional theory and materials basic to teaching music theory, reading, and ear training. Musical instruments, audio-visual devices as aids. Prerequisite: 12 credits in music theory and/or harmony.

NUCLEAR ENGINEERING (NUC E)

Warren F. Witzig, *Head of the Department*
231 Sackett Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty, Senior Members: Professors Diethorn, Foderaro, Jacobs, Levine, Palladino, Schultz, and Witzig; Associate Professors Kenney, Klevans, and Remick.

Graduate Faculty, Associate Members: Associate Professor D'Ardenne, Assistant Professors Jester and Robinson.

Fields of study are individually tailored, and engineering is emphasized through the study of reactor physics—computational methods, transport theory, and nuclear

design; plasma physics—waves, analysis, and fusion laboratory; shielding—Monte Carlo methods and two-body kinematics; reactor systems design—thermal, mechanical, and control; reactor fuels—configuration, radiation effects, and fuel cycle management; isotope utilization—activation analysis, chemical processes including copolymerization and nuclear medicine; plowshare applications; safety analysis—reactor siting, engineered safeguards, and nonlinear kinetics. The department offers three degrees at the Master's level: an M.S. with paper, an M.S. with thesis, and an M.Eng. The language and communications requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language and proficiency in English.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

NUCLEAR ENGINEERING (NUC E)

400. Nuclear Engineering Special Topics (1-12)
401. Introduction to Nuclear Engineering (3)
402. Introductory Reactor Analysis II (3)
410-411. Nuclear Reactor Theory (3 each)
415. Radionuclear Applications (3)
420. Radiological Safety (3)
430. Design Principles of Reactor Systems (3)
431. Synthesis of Nuclear Systems (3)
440-441. Nuclear Engineering Laboratory (3 each)
490. (E.E. 490) Introduction to Plasma Theory (3)

501. Reactor Engineering (3) Reactor controls, shielding of nuclear reactors, stress analysis of reactor materials, power cycle analysis, breeding, and advanced design considerations. Prerequisite or concurrent: Nuc.E. 411.

502. Reactor Engineering Laboratory (1-5) Reactor experiments devised to acquaint the student with reactor technology. Prerequisite or concurrent: Nuc.E. 411.

503. Thermonuclear Engineering (3) Binary fusion reactions; microscopic and macroscopic phenomena in a completely ionized gas; electromagnetic confinement; design, operation, and diagnostics of experiments. Prerequisite: Math. 452.

505. Reactor Instrumentation and Control (3) Neutron-detecting instruments and circuits; in-core power instrumentation; reactor control principles; control mechanisms; operational control problems. Prerequisite: Nuc.E. 411.

506. Two-Body Kinematics (3) Conservation laws of classical and quantum mechanics and their application to interactions between two bodies. Prerequisite: Math. 72.

507. Interaction of Radiations with Matter (3) Theory of the processes by which gamma rays, neutrons, and charged particles interact with electrons, atoms, and nuclei. Prerequisite: Nuc.E. 506.

508. Radiation Shielding (2) Radiation sources in reactor systems; attenuation of gamma rays and neutrons; deep penetration theories; Monte Carlo methods. Prerequisite: Nuc.E. 507.

509. Radiation Damage in Solids (2) Production of defects by high energy particles; nature of defects; diffusion and annealing in solids; macro property changes. Prerequisite: Nuc.E. 507.

511. Nuclear Reactor Materials (3) Philosophy, selection, technology, use, economics, and performance of materials of major interest in nuclear power reactors today. Prerequisite: Nuc.E. 411.

520. Reactor Analysis (3) Physical principles and mathematical methods of reactor analysis. Prerequisite: Nuc.E. 410.

521-522. Neutron Transport Theory (3 each) Derivation of Boltzmann equation for neutron transport; techniques of approximate and exact solution for the monoenergetic and spectrum regenerating cases. Prerequisite: Nuc.E. 410 or Phys. 406.

525. Nonlinear Reactor Kinetics (3) Intrinsic response of reactors to extreme reactivity insertions, mathematical models, physics of feedback coefficients, analysis of behavior of burst reactors. Prerequisite: Nuc.E. 411.

550. Special Topics in Nuclear Engineering (1-12) Organized studies in nuclear engineering with or without associated experimental work. Prerequisites: Math. 72, Phys. 406.

590. (E.E. 590) Theory of Plasma Waves (3) Solutions of the Boltzmann equation; waves in bounded and unbounded plasmas; radiation and scattering from plasmas. Prerequisite: Nuc.E. 490.

591. (E.E. 591) Plasma Theory (3) Advanced topics in kinetic theory, fluctuation theory, microinstability, and turbulence. Prerequisite: Nuc.E. 590.

PETROLEUM AND NATURAL GAS ENGINEERING (PNG E)

C. Drew Stahl
Head of the Department of Petroleum and Natural Gas
25 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Slobod and Stahl; Associate Professors Bissey, Burcik, and Farouq Ali.

Graduate Faculty, Associate Member: Assistant Professor Slater.

Areas of specialization include experimental and theoretical studies of water flooding and the newer methods for displacing oil from porous media, methods for calculating reservoir performance, scaled laboratory studies of reservoir phenomena, and drilling and well completion problems.

The language and communications requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Students who expect to enter graduate study in this field with a degree in another major should present 6 credits in geology, 15 in engineering science, and credit for mathematics through integral calculus. A limited number of deficiencies may be made up after admission. Certain closely related courses outside the department may be counted as petroleum and natural gas credits toward the degree.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

PETROLEUM AND NATURAL GAS (P N G)

400. Thesis (1-6)
410. Applied Reservoir Engineering (3)
420. Applied Reservoir Analysis (3)
421. Reservoir Engineering (3)
450. Drilling Design and Production Engineering (3)
475. Petroleum Engineering Design (3)
480. Production Process Engineering (3)
481. Natural Gas and Gasoline Plants (2)
485. Engineering in Secondary Recovery (3)
493. Engineering Evaluation of Oil and Gas Properties (3)

510. Solution of the Partial Differential Equations of Flow in Porous Media (3) The application of mathematical techniques to solve the partial differential equations of steady and unsteady state flow in porous media. Prerequisite: Math. 405.

511. Numerical Solution of the Partial Differential Equations of Flow in Porous Media (3) Differencing schemes for the partial differential equations of single-phase flow; application to flow of gas and mixing in porous media.

512. Numerical Reservoir Simulation (3-6) Mathematical analysis of complex reservoir behavior and combination drives; numerical methods for the solution of behavior equations; recent developments. Prerequisite: P.N.G. 510.

514. Optimization of Petroleum Recovery Processes (3) Optimum search methods, linear programming, nonlinear programming, dynamic programming, application to waterflooding, depletion drive, steam injection, gas cycling, miscible displacement. Prerequisite: P.N.G. 410.

515. Advanced Oil Recovery Techniques (3) Advanced oil recovery techniques including water-flooding, in-situ combustion, steam injection, hot-water injection, and miscible-phase displacement.

519. Design of Thermal Recovery Projects (3) Suitability of reservoirs for thermal oil recovery; case histories; design of in-situ combustion and steamfloods; thermal stimulation; shale oil recovery. Prerequisite: P.N.G. 515.

520. Phase Relations in Reservoir Engineering (3) Phase relations as applied to condensate and retrograde condensate reservoirs and to other problems in petroleum production.

525. Special Topics in Petroleum Engineering (2-6)

530. Natural Gas Engineering (1-3) Flow in producing or storage reservoirs; gas well testing; transmission systems; storage cycle; current developments. Prerequisite: P.N.G. 481.

*535. Seminar (1-3)

540. Special Studies in Petroleum Engineering (1-3) Supervised short study performed in the field, library, or laboratory covering any approved topic related to petroleum engineering.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in petroleum and natural gas studies are listed under Materials Science.*

* Credits to be arranged, 1 per term.

PHARMACOLOGY (PHARM)

ELLIOT S. VESELL, *Chairman of the Department*
The Milton S. Hershey Medical Center

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professor Vesell, Associate Professors Fritz and Greene.

Graduate Faculty, Associate Members: Assistant Professors Connor and Severs.

The department offers opportunities for research and courses in drug metabolism, endocrine pharmacology, neuropharmacology, cardiovascular pharmacology, clinical pharmacology, and general pharmacology. Emphasis is placed on molecular and physiological mechanisms by which drugs act in the body and by which the body transforms drugs.

The language and communications requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign languages.

A bachelor's degree reflecting a reasonable background in zoology or biology, mathematics, and chemistry is required; reading knowledge of one or two foreign languages is recommended, but not required. Applicants must provide complete transcripts and two letters of recommendation. Scores from the Graduate Record Examination and a personal interview are desirable. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

This program is offered only at The Milton S. Hershey Medical Center.

PHARMACOLOGY (PHARM)

501. PHARMACOLOGY (3) Lectures, discussions, and laboratory study of the mechanism of drug action in biological systems.

502. PHARMACOLOGY (4) Continuation of Pharm. 501.

504. DRUG METABOLISM (3) Study of chemical transformation of drugs within animal cells and drug metabolizing enzymes present in liver microsomes performing this function. Prerequisite: Pharm. 501.

506. PHARMACOLOGY OF ENDOCRINE ORGANS (3) Current concepts of interaction of endocrine tissue with endogenous compounds and pharmacological agents. Prerequisite: Pharm. 501.

507. PHARMACOLOGY OF PSYCHOACTIVE DRUGS (3) Current theories of mental diseases and pharmacological agents used to treat them will be covered. Prerequisite: Pharm. 501.

508. PHARMACOLOGY OF BIOLOGICALLY ACTIVE MONAMINES (3) The role of monamines in body function and alteration of their activity by drugs will be discussed. Prerequisite: Pharm. 501.

509. DEVELOPMENT OF THERAPEUTIC AGENTS (3) This course will deal with stages of drug development ranging from laboratory studies to routine human consumption.

512. CLINICAL PHARMACOLOGY (3) Drug therapy of cardiovascular, renal, and neural diseases will be discussed.

515. Human Genetics (2) Seminar-type presentations by students and staff on fundamental problems and current topics in human genetics.

540. Pharmacogenetics (3) Study of human responses to individual drugs.

550. Autonomic Nervous System Pharmacology (3) Study of drugs concerned with and acting on the sympathetic and parasympathetic nervous systems.

560. Pharmacology Seminar (1-3 per term) Student and staff seminar designed to familiarize medical and graduate students with current research developments in the field.

570. Special Topics (1-6) Introduction of students to the research laboratory and the scholarly pursuits of members of the staff.

590. Research (1-12) Individualized research conducted by students in departmental laboratories.

PHILOSOPHY (PHIL)

Carl R. Hausman, *Head of the Department*
247 Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty, Senior Members: Professors Anderson, Freund, Hausman, Johnstone, Kockelmans, and Rosen; Associate Professors Ford, Gotshalk, and Lingis.

Graduate Faculty, Associate Members: Associate Professors Price and Tsugawa; Assistant Professors Flay, Kennington, and Vaught.

A thorough grounding in the history of philosophy is desirable for all students. Specialization is possible in areas (such as aesthetics, metaphysics, ethics, social philosophy, logic, and history and philosophy of science); in movements of thought (such as rationalism, empiricism, idealism, phenomenology, and existentialism); or in any of the major figures in the history of western philosophy. Specialization is also possible in a joint program with the Department of Mathematics in logic and the foundations of mathematics. Undergraduate preparation to the extent of a strong minor is advisable. The department may waive the requirement of a thesis for an M.A. candidate.

The language and communications requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages or by comprehensive knowledge of one.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

PHILOSOPHY (PHIL)

406. Medieval Philosophy (3)
408. Studies in Social and Political Philosophy (3)
410. Studies in Greek Philosophy (3-6)
411. Studies in Modern Philosophy (3-6)
412. Studies in Contemporary Philosophy (3-6)
413. Philosophy of Literature (3)
414. Aesthetic Theory (3)

417. Nineteenth Century Philosophy (3-6)
419. Philosophical Backgrounds of American Thought (3)
420. Philosophy of History (3)
421. Classics of Scientific Methods (3)
422. Philosophical Logic (3)
424. Studies in Philosophy of Religion (3)
426. Metaphysics (3-6)
427. Advanced Ethics (3)
428. (Math. 428) Logical Theory (3)
429. Semantics: Philosophy of Language and Symbolism (3)
430. Philosophical Problems (1-9)
435. Religion and Science (3)

500. Ethics: Historical and Systematic (2-6) Critical study of some phase of ethical theory, or of some period of the history of ethics.

504. Social and Political Philosophy (3-6) Critical study of basic problems in their historical and functional setting.

505. Philosophy of Western Religion (3-6) The consideration of contemporary western religious concepts in terms of their Graeco-Judean traditions.

506. Seminar in Ancient Philosophy (3-6) Study of one or more important men or movements in ancient philosophy.

507. Seminar in Medieval Philosophy (3-6) Study of one or more important men or movements in medieval philosophy.

508. Seminar in Modern Philosophy (3-6) Men and movements in philosophy from the Renaissance through the nineteenth century.

509. Seminar in Contemporary Philosophy (3-6) Men and movements in twentieth century philosophy.

511. Principles of Experimental Inference (3-6) Science as controlled inquiry; types of scientific procedures in formal, physical, and sociocultural science.

512. Advanced Topics in Philosophy of Science (3-6) Crucial problems in the theory of science and scientific method.

514. Seminar in Nineteenth Century Philosophy (3-6) Study of a philosopher or philosophical movement of the nineteenth century.

515. Philosophical Method (3-6) Methods proposed by classical and contemporary thinkers for reaching philosophical conclusions: deductive, inductive, dialectical, pragmatic, intuitive.

516. Seminar in Aesthetics (3-6) Problems and theories in the nature of art.

526. Seminar in Metaphysics (3-6) Formulation and analysis of metaphysical problems in the various fields of philosophy.

530. Philosophy Research Seminar (1-12) Study of selected philosophical problems with an emphasis on techniques of philosophical research.

550. (Math. 550) Foundations of Mathematical Logic (3) The nature of logical basis of mathematics; critical examination and development of the basic parts of logical calculus. Prerequisite: Math. 480 or Phil. 428.

554. (Math. 554) Logic and Metamathematics I (3) Completeness, Löwenheim-Skolem, Herbrand, and compactness theorems; first-order theories; categor-

icity, elimination of descriptions; decidability; algebraic and geometric applications. Prerequisite: Phil. 428.

556. (Math. 556) Recursion Theory (3) Recursive functions; normal form, enumeration and separation theorems; partial recursive functions; recursion theorems; special recursive functions; alternate formulations; related topics. Prerequisite: Phil. 428.

557. (Math. 557) Logic and Metamathematics II (3) Arithmetization; Gödel and Tarski incompleteness theorems; undecidability results; Gentzen-type systems and consistency results. Prerequisite: Phil. 428.

PHYSICAL EDUCATION (PH ED)

Betty van der Smissen
Associate Dean for Graduate Study and Research
275 Recreation Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors Buskirk, Coombs, Gross, Harnett, E. Hunt, Mendez, Nelson, Storey, and van der Smissen.

Graduate Faculty, Associate Members: Professor Stoedefalke; Associate Professors Gray, Kollias, Lucas, Lundegren, Magnusson, Morehouse, and Nicholas.

Areas of specialization include (1) adapted physical education; (2) administration-supervision (methods and materials, curriculum construction, intramurals, and interscholastics); (3) biomechanics (applied anatomy and kinesiology); (4) health education; (5) history of sport and physical education; (6) measurement and test construction; (7) motor learning; (8) physiology of exercise (physical conditioning, physical fitness, and performance stress); (9) psychosocial foundations of physical activity; and (10) recreation and parks.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Admission to the M.S. program requires a major in physical education or its equivalent in comparable course work. Especially desirable is course work in mathematics plus a concentration on the physical, biological, behavioral, or social sciences, depending upon the intended areas of specialization. Admission to the M.Ed. program requires a minimum of 18 credits in health and physical education plus 18 credits in education and educational psychology combined, including practice teaching. A year or more of field experience is recommended.

Admission to doctoral study requires the master's degree or its equivalent, demonstrated research ability in the form of a thesis or published research, and acceptable performance on the Aptitude Test of the Graduate Record Examination or other specified tests. A student who has earned a master's degree in recreation and parks and meets the above requirements may enter a doctoral program in physical education with specialization in recreation and parks. The language and communications requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

See also "Recreation and Parks."

HEALTH EDUCATION (HL ED)

411. Principles and Methods of Teaching Safety Education (3)
456. Advanced Techniques in School Community Health Education (3)
496. Special Projects (1-6)

501. Health Implications in the Growth and Development of School Children (3) Child growth and development emphasis for teachers; medical inspection and examination; preschool program; early habit formations; behavior problems; cooperation of parents, teachers, and children. Prerequisite: Hl.Ed. 215.

503. Health Implications in Maturity and Aging (3) Changes in the human body in maturity and aging. Theories and mechanisms of physiologic aging with implications for health education. Prerequisite: Hl.Ed. 501.

PHYSICAL EDUCATION (PH ED)

400. Adaptive Physical Education (3)
420. Psychosocial Dimensions of Physical Activity (3)
450. Current Research Literature in Physical Education (3)
452. Analysis of Physical Education Activities for the Elementary School (3)
455. Statistical Methods in Health, Physical Education, and Recreation (3)
456. Physical Fitness Appraisal (3)
460. Methods and Principles of Athletic Coaching (3)
462. Administration of Athletic Programs (2)
470. History and Theory of Dance in Education (2)
480. Advanced Anatomy and Physiology, Applied (3)
483. Principles of Body Mechanics (3)
484. Kinesiology (3)
489. Intramural Athletics (3)
490. Introduction to Tests and Measurements in Health and Physical Education (3)
491. Organization and Administration of Health and Physical Education in Schools (3)
495. History of Sport in American Society (3)
496. Special Projects (1-6)

500. (Rc.Pk. 500) Individual Study and Research Projects (1-10) Prerequisite: Ph.Ed. 530.

530. (Rc.Pk. 530) Research Techniques in Health and Physical Education and Recreation (3)

531. Research in Health and Physical Education and Recreation (3) Prerequisite: Ph.Ed. 530.

532. Tests and Measurements in Physical Education (3) Critical study of tests and measurements available in physical education; methods of constructing and evaluating new tests and measurements. Prerequisite: Ph.Ed. 490.

534. Studies in Curriculum Construction in Physical Education (3) Principles and methods of curriculum building in physical education; different psychological and educational points of view, organizing a course of study committee, making units of instruction.

535. Modern Foreign Systems of Physical Education (3) Comparative analysis of national and local programs and systems of physical education in foreign countries. Prerequisites: Ph.Ed. 534, 595.

550. Seminar in Health and Physical Education (1-6) An in-depth analysis of current problems confronting the profession.

560. Administrative Problems of Physical Education in Schools (3) Solutions to problems emerging from the administration of physical education in schools, fitting physical education in the school's schedule, awards and budgets. Prerequisite: Ph.Ed. 491.

565. Neuromuscular Performance (3) Integrative action of the neural and muscular systems in effecting human movement with emphasis on motor performance. Prerequisites: Ph.Ed. 480, 490.

575. Motor Performance of the Handicapped (3) Motor performance of physically handicapped and mentally retarded. Activities and therapeutic exercises for the formulation of individualized programs. Prerequisites: Ed.Ser. 409, E.E.C. 410.

576. Internship in Adapted Physical Education (3) Supervised internship in recreational, educational, or clinical situations; assessment of motor performances, evaluation of activities, and staff conference participation.

581. Biomechanics (3) Kinetic and kinematic analyses of human motion utilizing electromyography and stroboscopic-photographic techniques. Prerequisite: Ph.Ed. 480.

582. Advanced Kinesiology (3) Analysis of sports movements utilizing cinematography, electronic devices, and related research instruments.

583. Special Topics in Biomechanics (1-6) Critical review of current research in biomechanics, culminating in individual research projects. Prerequisite: Ph.Ed. 581 or 582.

585. (Phsio. 585) Applied Physiology (3) Presentation of current thinking on physiological mechanisms with emphasis on physically active man. Prerequisite: 3 credits in physiology at the 400 or 500 level.

586. (Phsio. 586) Research Methods in Applied Physiology (3) Historical and current procedures for evaluation of cardio-pulmonary function, metabolism, and thermal balance in man; lecture, demonstration, and student laboratory. Prerequisite: 3 credits in physiology at the 400 or 500 level.

588. (Phsio. 588) Special Topics in Applied Physiology (1-6) Critical discussion and evaluation of current research in applied physiology. Prerequisite: Ph.Ed. 585.

589. (Phsio. 589) Physiology of Pulmonary Respiration (2) Physiology of the lung including physical and chemical properties, synthesis of cellular constituents, gas exchange, and effects of unusual environments. Prerequisite: 3 credits of physiology at 400 or 500 level.

595. Philosophy of Health and Physical Education and Recreation (3) Prerequisite: Ph.Ed. 491 or Rc.Pk. 465.

PHYSICAL SCIENCE (PH SC)

JOHN P. MCKELVEY
Chairman of the Committee on Physical Science
101 Osmond Laboratory

Degrees Conferred: D.Ed., M.Ed.

The M.Ed. program, designed to meet the needs of secondary school science teachers requires at least 24 credits chosen from chemistry, physics, astronomy, mathematics, earth sciences, and biological sciences, including at least 9 each in chemistry and physics. In addition, a minor of at least 6 credits in education is required. The student must also complete a satisfactory term paper on a subject approved by the committee.

For admission to either the M.Ed. program or the D.Ed. program, the student is expected to have completed two years of college chemistry, one year of college physics at a level requiring calculus, mathematics through differential equations, and 18 credits in appropriate education and psychology courses.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

For the D.Ed. degree, the student is required to complete 24 credits in physical science, including chemistry, earth sciences, mathematics, and physics, which *may* be (but are not required to be) in courses designed specifically for teachers. He is expected, beyond this, to complete 36 credits in standard 400- and 500-level courses, which *may not* be courses designed primarily for teachers; of these, 12 credits must be in chemistry, 12 in physics, and 12 in science and mathematics courses approved by the student's doctoral committee. In addition, 15 credits in education courses and 15 credits of thesis research are required. The student's selection of science courses should include at least 6 credits in experimental physics or chemistry.

A limited amount of work can be done during summer terms or off-campus, but a candidate must plan to be on the University Park Campus for at least four consecutive terms after he has been accepted as a D.Ed. candidate. The student will be required to take a candidacy examination after having completed about 30 credits of graduate study, and a comprehensive examination after having completed his required course work. He must also present and defend a thesis, which may be either an experimental study in physics or chemistry, or an investigation of a problem in the teaching of physical science.

See also Earth Sciences, Chemistry, Mathematics, and Physics.

PHYSICS (PHYS)

DAVID H. RANK, *Head of the Department*
101 Osmond Laboratory

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors Barsch, Bleuler, Cutler, Feuchtwang, Frankl, Henisch, Herman, Kazes, Kendall, McCubbin, McKelvey, Müller, Polo, Pratt, Rank, Skudrzyk, Vedam, and Wiggins; Associate Professors Atwater, Eastman, Fleming, Freed, Madjid, McCammon, Strother, Thwaites, Weber, and Whitfield.

Graduate Faculty, Associate Members: Associate Professor Shaw, Assistant Professors Graetzer and Lochstet.

Graduate instruction and research opportunities are available in visible and infrared spectroscopy, laser physics, solid state, field emission, thermionic emission, photoelectric emission, acoustics, low-temperature physics, nuclear physics, physics of high polymers, and of carotenoids, electron spin resonance of solids, and various phases of theoretical physics.

The language and communications requirement for the Ph.D. degree may be satisfied by reading or introductory knowledge of two foreign languages chosen from French, German, and Russian.

A bachelor's degree in physics or an allied field is required for admission to the M.S. and Ph.D. programs. Students who lack some of the usual upper-class undergraduate courses in physics may be requested to take additional course work without degree credit.

For admission to the M.Ed. program a student is required to have completed one year of general college physics plus two acceptable intermediate courses in physics, mathematics through integral calculus, and 18 credits in education and related psychology. The program requires at least 18 credits in physics, including approved laboratory work such as Phys. 560; at least 3 credits each in chemistry and mathematics; and at least 6 credits in education. With the approval of the head of the department the no-thesis option is available for the M.S. degree.

Students with a 2.50 junior-senior average in physics and mathematics will be considered for admission to the M.S., D.Ed., and Ph.D. programs. He will be considered with a 2.50 junior-senior average in all courses for admission to the M.Ed. program. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. Exceptions may also be made, at the discretion of the department, for applicants for doctoral programs who have satisfactorily completed master's degrees at other institutions.

PHYSICS (PHYS)

400. Intermediate Electricity and Magnetism (4)
402. Electronics (4)
406. Nuclear Physics (3)
410. Introduction to Quantum Mechanics (3)
412. Solid State Physics I (3)
413. Solid State Physics II (3)
419. (A.M. 419) Theoretical Mechanics (3)
420. Classical Thermodynamics (2)
421. Thermal Physics (2)
433. Mechanics and Fluid Physics for Teachers (3)
435. Electricity and Magnetism for Teachers (3)
437. Heat, Wave Motion, and Sound for Teachers (3)
439. Elementary Survey of Modern Physics for Teachers (3)
443. Intermediate Acoustics (3)
454. Atomic and Nuclear Physics (3)
456. Atomic and Molecular Physics (3)
457. Experimental Physics (1-2 per term)
458. Intermediate Optics (4)
461. (A.M. 461) Theoretical Mechanics (3)
467. Intermediate Electricity and Magnetism (3)
470. Special Topics (1-9)
471. Quantum Theory of Atoms and Molecules (3)

509. Physics Seminar (1-3 per term) Topics from current research.

512-513. Introduction to the Quantum Theory of Solids (3 each) Energy

band theory; electrical, optical, and magnetic properties; lattice dynamics; transport theory. Prerequisites: Phys. 412, 517.

517. Statistical Mechanics (3) Classical and quantum statistics; statistical thermodynamics; the Boltzmann transport equation; methods illustrated with applications to physical problems. Prerequisites: Phys. 420, 561.

518. Advanced Topics in Thermodynamics and Statistical Mechanics (3) Selected topics related to nonequilibrium thermodynamics, many-body problem, fluctuations, and statistical theory of random processes. Prerequisite: Phys. 517.

524. Physics of Semiconductors (3) Band structures, theory of electron and hole conduction, transport properties, excess carrier distributions, p-n junctions, metal-semiconductor contacts, semiconductor surfaces. Prerequisite: Phys. 412.

525. Methods of Theoretical Physics (3) Vector and tensor analysis; generalized coordinate systems; matrices and linear vector spaces of finite and infinite dimensionality; calculus of variations. Prerequisite: advanced calculus.

526. Methods of Theoretical Physics (3) Continuation of Phys. 525: complex variables; Hilbert space; Green's functions; orthogonal functions and boundary value problems. Prerequisite: Phys. 525.

530. Theoretical Mechanics (3) Newtonian mechanics; Lagrange's equations, Hamilton's principle; Hamilton's equations; coupled systems; waves in strings, central field problem; rigid bodies; elasticity; hydrodynamics.

533. Theoretical Acoustics (3) Vibrating systems; transmission of disturbances through elastic and viscoelastic media. Prerequisite: Phys. 530.

550. (A.M. 550) Applied Group Theory (3) Representations of discrete and continuous groups, applications to theoretical physics and differential equations, varying emphasis on the specific applications. Prerequisite: A.M. 510.

553-554. Nuclear Physics (3 each) Discussion and theoretical interpretation of basic experiments involving atomic nuclei and nuclear radiations. Prerequisite: Phys. 562.

557. Electricity and Magnetism (3) Electro- and magnetostatics, Maxwell's equations, boundary value problems, electric and magnetic properties of material media.

558. Advanced Electricity and Magnetism (3) Energy and momentum in the field, radiation theory, classical relativistic electron theory. Prerequisite: Phys. 557.

560. Research Problems (1-10) Introduction to research through individual assignments.

561-562. Quantum Mechanics (3 each) The basic theory of wave and matrix mechanics, approximation methods, applications. Prerequisite: Phys. 530.

563-564. Advanced Quantum Mechanics (3 each) Relativistic wave equations, quantum field theory, other advanced quantum theoretical topics. Prerequisite: Phys. 562.

571. Atomic Physics (3) Experimental basis of modern physics; atomic spectra and structure, nuclear phenomena.

575. Special Topics (1-3 per term) Theoretical studies in any field of modern physics with or without associated experimental work. Prerequisite: Phys. 456.

PHYSIOLOGY (PHSIO)

ADAM ANTHONY
Chairman of the Committee on Physiology
418 Life Sciences Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Almquist, Anthony, Baumgardt, Bortree, Buskirk, Buss, Hale, Jeffries, Mendez, Morgan, Mueller, and H. Schraer; Associate Professors Amann, Cornwell, Dunson, Hymer, Leach, McCarl, Mortimore, B. Pubols, R. Schraer, Smyth, Strother, and Wickersham; Assistant Professor Gaffney.

Graduate Faculty, Associate Members: Associate Professors Kollias, Nicholas, and Zarkower; Assistant Professors Eberhart, Jefferson, Mitchell, Neely, Neff, Rhoades, and Scholz; Mrs. L. Pubols.

This is an interdisciplinary program designed to enable students to obtain an integrated series of courses encompassing both the fundamentals of physiology and advanced training in a specialized area.

Graduate instruction in physiology is under the direction of a program committee composed of graduate faculty representing several departments or groups actively participating in the physiology program, including the areas of animal science, biochemistry, biophysics, and zoology, and the Human Performance Research Laboratory. The instructional staff is composed of the program committee as well as faculty in those departments offering graduate courses in various areas of specialization in physiology. The program, including courses, laboratory experience, and original research, is designed for completion in three to four academic years. The language and communications requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests.

The entering student who lacks adequate preparation in chemistry, mathematics (through calculus), physics, or biological science must make up the deficiency early in his graduate program. All candidates (master's and doctoral) must complete a general basic laboratory course in physiology (combined cellular, mammalian, and comparative) before choosing an area of specialization. Possible areas of specialization are cellular and subcellular physiology, environmental physiology, endocrinology, applied physiology (human performance), physiology of nutrition and metabolism, neurophysiology, or comparative physiology. The graduate committee for majors shall be appropriately represented by members of the physiology program committee and those of the area of specialization who shall have the responsibility and jurisdiction for determining the course program and research acceptable in satisfying degree requirements. The no-thesis option is available for the M.S. degree.

The following courses are available for physiology majors, and their descriptions may be found under the offerings of several departments: Anthy. 401; A.Ntr. 401, 402, 505; Bioch. 401, 402, 417, 436, 437, 438, 501, 517, 519, 520, 521; Biol. 401, 470, 471, 475, 538, 539, 541, 575, 583; Bphys. 473, 474, 475, 580, 588; D.Sc. 427, 431, 512, 515, 521; Ent. 411; F.N. 452, 457, 459, 552, 557; Micrb. 401, 508; Psy. 402, 403, 503; V.Sc. 535.

The following courses in physiology and biochemistry are offered at The Milton S. Hershey Medical Center: Anat. 505, 510, 535; Bchem. 502, 503, 513, 523, 540, 570, 590; Phsio. 520, 521, 525, 530, 550, 570, 590. Descriptions of these courses may be found on pages 93, 94, 108, and 295.

PHYSIOLOGY (PHSIO)

501. Seminar (1 per term)

510. Special Topics in Physiology (1-6)

571. (Biol. 571) Animal Physiology (2) Physiology and fluid transport mechanisms; examination of the distribution and regulation of body fluids, blood and hemodynamics. Prerequisite: 3 credits in physiology.

572. (Biol. 572) Animal Physiology (2) Examination of nutrition, metabolism, and respiration as they relate to subcellular, cellular, and organ organizational levels of the whole animal. Prerequisite: 3 credits in physiology.

573. (Biol. 573) Animal Physiology (2) Detailed examination of animal reproduction, endocrine secretion and control, neural muscular activity, central nervous system correlates, and special senses. Prerequisite: 3 credits in physiology.

574. (Biol. 574) Animal Physiology Laboratory (1-6) Selected problems using advanced physiological techniques to study transport mechanisms, circulation, excretion, respiration, metabolism, and neuroendocrines. Prerequisite: Biol. 473.

585. (Ph.Ed. 585) Applied Physiology (3) Presentation of current thinking on physiological mechanisms with emphasis on physically active man. Prerequisite: 3 credits in physiology at the 400 or 500 level.

586. (Ph.Ed. 586) Research Methods in Applied Physiology (3) Historical and current procedures for evaluation of cardio-pulmonary function, metabolism, and thermal balance in man; lecture, demonstration, and student laboratory. Prerequisite: 3 credits in physiology at the 400 or 500 level.

588. (Ph.Ed. 588) Special Topics in Applied Physiology (1-6) Critical discussion and evaluation of current research in applied physiology. Prerequisite: Phsio. 585.

589. (Ph.Ed. 589) Physiology of Pulmonary Respiration (2) Physiology of the lung including physical and chemical properties, synthesis of cellular constituents, gas exchange, and effects of unusual environments. Prerequisite: 3 credits of physiology at 400 or 500 level.

PLANT PATHOLOGY (PPATH)

James Tammen, *Head of the Department*
211 Buckhout Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Bloom, Boyle, Cole, Kneebone, Lewis, Mills, P. Nelson, R. Nelson, Schisler, Tammen, and Wood; Associate Professors Lukezic and Merrill.

Graduate Faculty, Associate Members: Adjunct Professor Hyre, Associate Professors Stouffer and Wuest, Assistant Professor Lacasse, and Adjunct Assistant Professor Leath.

Plant pathology is the study of disease in plants and concerns the dynamic interaction between the plant, the causal agent (bacteria, fungi, viruses, nematodes, etc.), and their environments. A student prepares for a professional career in research, teaching, extension, or industry through advanced studies of the principles of plant

infection, the physiology of disease in plants, the ecology of root diseases, the nature and inheritance of disease resistance in plants, epidemiology, ecology and physiology of air pollution injury to plants, or plant disease control by biological or chemical means. A student also may specialize in the nature and control of the diseases of forest trees, agronomic or horticultural crops, and commercial mushrooms. Advanced studies in applied mycology, related to the production of the commercial mushroom, also may be taken. Modern, well-equipped laboratories, controlled environment facilities and greenhouses, and well-developed field research areas are available for graduate study.

The language and communications requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

For admission a student must present 42 credits in the natural sciences, including a minimum of 15 credits in the plant sciences and a minimum of 15 credits in mathematics, chemistry, or physics. Students with a strong background in agronomy, biochemistry, biophysics, botany, forestry, genetics, horticulture, or microbiology are usually well prepared for advanced study in plant pathology.

Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests.

PLANT PATHOLOGY (PPATH)

408.	Plant Pathological Techniques (3)	*Mr. Bloom*
410.	Intermediate Plant Pathology (1)	*Mr. Wuest*
411.	Diseases of Ornamental and Floricultural Plants (2)	*Mr. P. E. Nelson*
412.	Advanced Forest Pathology (2)	*Mr. Merrill*
413.	Diseases of Field Crops (2)	*Mr. Leath*
414.	Diseases of Fruit and Vegetable Crops (2)	*Mr. Boyle*
420.	Plant Pathogenic Bacteria (3)	*Mr. Lukezic*
422.	Introduction to Plant Virology (3)	*Mr. Boyle*
424.	Environmental Pathology (3)	*Mr. Lacasse*
429.	Phytonematology (3)	*Mr. Bloom*
430.	History of Plant Pathology (2)	*Mr. Merrill*

501. Clinical Plant Pathology (1-3) Diagnosis and prognosis of disease; observe and evaluate the implementation of control practices. Prerequisite: P.Path. 408. *Mr. Wuest*

518. Special Problems (1-12) The prosecution of an assigned problem under the guidance of a staff member. Throughout the year as arranged. By appointment.

531. Plant Pathology Seminar (1 per term) Selected topics of current research, history, and contemporary trends in plant pathology. *Mr. Tammen*

540. Plant Disease Control (3) Principles of plant disease control, including theoretical considerations involved in control by chemical and nonchemical means. *Mr. Cole*

541. Physiology of Plant Disease (3) Physiology of the diseased plant, including the host response to the pathogen and parasitic properties of the pathogen. Prerequisite: Biol. 443. *Mr. Lukezic*

542. Epidemiology of Plant Diseases (4) Disease development in populations of plants, with emphasis on the impact of environment and control practices on rate of development. Prerequisite: 9 credits in plant pathology. *Mr. Wood*

543. Pathogen Variation and Host Resistance (3) Mechanisms and implications of genetic variation in plant pathogens related to breeding for disease resistance in plants by genetic means. *Mr. R. R. Nelson*

544. Pathological Plant Anatomy (2) Structural manifestations occurring in diseased plants. Prerequisites: Biol. 407, P.Path. 408. *Mr. P. E. Nelson*

560. Principles of Plant Pathology (3) Open-ended discussions of concepts of plant pathology, with emphasis on their interrelationships and their significance to the science. *Mr. R. R. Nelson*

POLITICAL SCIENCE (PL SC)

Robert S. Friedman, *Head of the Department*
107 Social Sciences Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty, Senior Members: Professors Albinski, Aspaturian, Atwater, Brown, Friedman, Mowitz, and Silva; Associate Professors Kochanek and Petras.

Graduate Faculty, Associate Members: Associate Professors Keynes and LaPorte; Assistant Professors Chang, Lee, and Ricci.

M.A. candidates will be comprehensively examined in American politics, comparative politics, international relations, political philosophy, or public administration. Candidates offering the thesis plan will also offer course work in one other of these substantive fields, or from among selected empirical theory-methodology courses. Candidates offering the non-thesis plan will offer course work in two of the above six fields. Ph.D. candidates will be comprehensively examined in four of the above fields, or in three departmental fields, and in a minor field or fields. Course work in empirical theory and scope and methodology is required. The language and communications requirement for the Ph.D. may be satisfied by competence in approved skills selected from among foreign languages, statistics or mathematics, and computer science.

Students with a 3.00 junior-senior average and appropriate course backgrounds, including at least the equivalent of 12 credits in political science, will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. At the master's level two letters of recommendation and scores on the Graduate Record Examination (disciplinary, verbal, and quantitative ability) are required. Admission to the Ph.D. program will entail evaluation of two letters of recommendation, scores on the Graduate Record Examination (disciplinary, verbal, and quantitative ability), and previous scholastic performance.

POLITICAL SCIENCE (PL SC)

401. Political Behavior (3) *Messrs. Keynes and King*
403. The Legislative Process (3) *Mr. Keynes*
411. American Political Theory (3) *Messrs. Ricci and Spence*
412. International Organization: Economic and Social Functions (3) *Mr. Atwater*
413. Government and Politics of the Soviet Union (3) *Messrs. Aspaturian, Atwater, and Gilberg*
414. Foreign Policy of the Soviet Union (3) *Mr. Aspaturian*

415. International Organization: Political and Security Functions (3-6) *Miss Loomis; Messrs. Aspaturian, Atwater, and Brown*
416. International Law (3) *Miss Loomis*
417. American Local Government and Administration (3) *Messrs. Cook, Johnson, and Lee*
418. International Relations Theory (3) *Miss Loomis*
419. Bureaucracy and Public Policy (3) *Messrs. Friedman, Johnson, and Lee*
425. Government and Politics of the American States (3) *Messrs. Friedman and Hennessy*
426. Political Parties (3) *Miss Silva*
427. Political Opinion (3) *Miss Silva and Mr. Hennessy*
431. Ancient and Medieval Political Theories (3) *Messrs. Ricci and Spence*
433. (L.M.R. 433) The Law of Labor-Management Relations (3)
441. Anglo-American Legal Systems (3) *Mr. Keynes*
442. American Foreign Policy (3) *Messrs. Atwater and Brown*
443. Current Problems in American Foreign Policy (3) *Messrs. Atwater and Brown*
444. Government and the Economy (3) *Mr. Hennessy*
445. Administrative Law (3) *Mr. Boyan*
447. Constitutional Law: The Federal System (3) *Miss Silva*
448. Constitutional Law: First Amendment Freedoms (3) *Mr. Boyan*
450. Canadian and Australian Politics and Foreign Policies (3) *Mr. Albinski*
451. Comparative Political Analysis (3) *Mr. Albinski*
452. Governments and Politics of Eastern Europe (3) *Mr. Gilberg*
453. Political Processes in Underdeveloped Systems (3) *Messrs. Kochanek, LaPorte, and Petras*
454. Government and Politics of Africa (3) *Messrs. Brown and Kingsland*
455. Governments and Politics of Western Europe (3) *Mr. Gilberg*
456. Politics and Institutions of Latin-American Nations (3) *Mr. Petras*
457. International Politics of Latin America (3-6) *Mr. Petras*
458. Government and Politics of East Asia (3-6) *Mr. Chang*
459. Government, Politics, and International Relations of South Asia (3) *Mr. Kochanek*
460. Liberal and Democratic Political Theory (3) *Messrs. Ricci and Spence*
461. Authoritarian and Elitist Political Thought (3) *Messrs. Ricci and Spence*
462. Marxist and Socialist Political Theory (3) *Messrs. Ricci and Spence*
468. International Relations of East Asia (3)
469. International Relations in South Asia (3-6) *Mr. Chang*
473. Constitutional Law: Civil Rights (3) *Miss Silva and Mr. Boyan*
499. Foreign Study in Government (2-6)

500. Political Power (3-6) Subject to be announced.

505. Executive Power (3-6) *Miss Silva*

509. Scope and Method of Political Science (3-6) *Mr. King*

512. Comparative Political Systems (3-9) *Messrs. Albinski, Kochanek, and Petras*

513. Seminar in Comparative Political Parties (3-6) Nature, function, organization, and leadership of parties; party systems, political culture, voting, and the institutional framework. *Mr. Albinski*

515. International Politics (3-6)

516. Seminar in International Relations Theory and Methodology (3) A

detailed analysis of major traditional and contemporary theory-building efforts and contemporary research techniques and orientations in international relations.

517. International Organization (3-6) *Messrs. Aspaturian and Atwater*

521. Modern Democratic Political Theory (3-6) *Mr. Ricci*

522. Comparative Foreign Policies (3-6) Major policies of selected nations which bear upon the search for international peace and security. *Mr. Aspaturian*

523. Soviet Political Behavior (3) Forces which shape rivalries for power; decision-making processes; areas of agreement and dissent. *Mr. Aspaturian*

524. Foreign Policies of the Soviet Bloc (3-6) Major policies, the decision-making process, and the impact upon component members and external rivals for power. *Mr. Aspaturian*

525. Comparative American State and Local Politics (3-6) Literature and research in comparative state and local political systems in the United States. *Mr. Friedman*

527. Politics and Legislative Behavior (3-6) Social factors which shape and determine the attitudes and decisions of American legislators and legislative bodies. *Mr. Keynes*

528. (Ed.Adm. 528) Politics and Education (3) Social forces which shape the educational system and determine national, state, and local educational policies.

529. Federal Systems (3-6) Features of the American federal system compared with those of other nations using the federal form.

530. Public Law (3-6) The nature of law and its role in modern society. *Miss Silva*

531. Marxism and Political Socialist Theories (3) A systematic analysis and appraisal of major premises and deductions. *Messrs. Aspaturian and Ricci*

532. Empirical Political Theory (3-6) The impact of scientific method upon traditional political thought. *Mr. Keynes*

546. Judicial Process (3) Court functions in the political process; sources and limits of judicial power; perceptions of the judicial role; judicial decision making. Prerequisite: 12 credits in political science. *Miss Silva and Mr. Keynes*

554. African Political Systems (3-6) Impact of European colonialism; cultural and anthropological factors in political development; modernization and analysis of selected problems in contemporary Africa. Prerequisite: 3 credits of comparative government or international relations at the 400 level. *Mr. Brown*

571. Theory of Public Administration (3-6) The role of the executive in modern government; the objectives of public administration; theories of administrative organization and practice. *Mr. Mowitz*

572. International Development Administration (3-6) The execution of foreign policies through national and international public and private organizations. *Mr. LaPorte*

573. Comparative Public Administration (3-6) Administrative systems of selected nations on a functional basis; relationship between culture, economic and social systems, and public administration. *Mr. LaPorte*

574. Seminar in the Administration of United States Foreign Affairs (3)

Effect of cross-cultural operations on the normal process of administration of United States foreign affairs. *Messrs. Brown and LaPorte*

575. Government Manpower Management (3) Government personnel systems; current trends and problems; essentials of recruitment, classification and pay, ratings, supervision, training, and discipline.

576. Government Fiscal Decision Making (3) The role of the executive in fiscal planning; budget preparation; expenditure control; tax assessment and collection; investment of public funds.

577. Organization and Systems Management (3) Principles of government organization; management surveys; work measurement; methods of achieving efficiency and economy. *Mr. Mowitz*

578. Urban Administrative Systems (3) Urban areas as administrative and policy systems; urban responses to problems of policy planning and implementation; approaches to urban analysis.

579. Methods of Analysis and Measurement in Public Administration (3) Examination and application of analytical techniques for evaluating organizational performance and program effectiveness in government agencies. *Mr. Cook*

580. Internship in Public Administration (6)

584. Research Seminar in Public Administration (1-3) Application of research methods to problems of organization, management, and policy in public agencies; design and preparation of research project.

594. Readings in Political Science (1-6) Directed readings in selected areas of the discipline.

595. Research in Political Science (1-6) Directed research in selected areas of the discipline.

POULTRY SCIENCE (PTYSC)

Kenneth Goodwin, *Head of the Department*
105 Weaver Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Bressler, Buss, Goodwin, Hale, and Mueller; Associate Professors Leach and MacNeil.

Graduate Faculty, Associate Member: Assistant Professor Graves.

The department offers two types of graduate programs: (1) a program in poultry science, with one of the following major fields of interest: genetics, physiology, nutrition, behavior, food science, or poultry management; and (2) an interdepartmental program in one of the following disciplines: genetics, physiology, food science, or animal nutrition.

In either case, the student's major program and his thesis research will be under the direction of a faculty member in the Department of Poultry Science. The language and communications requirement for the Ph.D. degree may be satisfied by reading ability in one foreign language.

Admission requirements include 30 credits in biology, chemistry, mathematics, and physics. Students with a 2.50 junior-senior average and with appropriate course back-

grounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

POULTRY SCIENCE (PTYSC)

402. Special Topics (3-12)
405. Poultry Production Technology (3) *Mr. Mueller*
462. (Biol. 462, Psy. 462) Animal Behavior—Ethology (3)
463. (Biol. 463, Psy. 463) Animal Behavior Laboratory (1-2)

502. Advanced Poultry Nutrition (2-4) *Mr. Leach*

503. Advanced Poultry Farm Management (2-4) *Mr. Bressler*

504. Poultry Meat and Egg Technology (2-6) Prerequisites: Fd.Sc. 212 and 2 additional credits in poultry science. *Mr. MacNeil*

582. (Biol. 582, Psy. 582) Research in Animal Behavior (2-6 per term) Research in special areas of animal behavior involving field or laboratory work. *Messrs. Graves and Hale*

597. Research in Poultry Science (1-9) Prerequisite: 9 credits in poultry science.

Note: *See Animal Science under "Other Elective Graduate Courses." Also see Food Science.*

PSYCHOLOGY (PSY)

Merrill E. Noble, *Head of the Department*
417 Psychology Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Cofer, Gorlow, Guthrie, Hale, Hall, Harris, Leibowitz, Lundy, Mitzel, Noble, Palermo, Sherif, Taylor, Thevaos, Trumbo, Urban, and Warren; Associate Professors Cornwell, Draguns, Freeman, Schipper, Seibel, Stern, and Thomas; Mr. Greenhill.

Graduate Faculty, Associate Members: Associate Professors Dubin, Piers, and Whaley; Assistant Professors Berman, Kirchner, Landy, Martin, and Sample.

Graduate instruction and research opportunities are available in the following areas of psychology: general experimental, physiological and comparative, animal learning, measurement and statistics, perception, social and personality, developmental, child, clinical, industrial and business, decision making, engineering and human factors, verbal learning, and psycholinguistics.

The language and communications requirement for the Ph.D. degree does not specify a foreign language but a student must demonstrate proficiency in English.

Special research and training facilities include the Penn State Anechoic Chamber, the University Computation Center, the Animal Behavior Laboratory, the Psychology Clinic, the Division of Counseling, and the Special Education unit.

Requirements for admission include a broad undergraduate preparation, a minimum of 12 credits in psychology, and a satisfactory graduate student rating on the Miller Analogies Test, and the Graduate Record Examination (General). Students with a

3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Applicants with master's degrees will have their admission evaluated with emphasis on the quality of their graduate programs.

PSYCHOLOGY (PSY)

402. Sensation and Perception (3) *Mr. Freeman*
403. Introductory Physiological Psychology (3) *Mr. Cornwell*
404. Learning and Motivation (3)
405. The Experimental Psychology of Visual Perception (3) *Mr. Leibowitz*
406. Experimental Social Psychology (4)
408. Comparative Psychology (2-4)
409. Techniques in Laboratory Experimentation (2-6)
410. History of Psychology (3) *Messrs. Freeman and Leibowitz*
412. Abnormal Psychology (3)
413. Biographical Psychology (3) *Mr. Harris*
415. Intermediate Experimental Design (3)
417. Social Psychology (3)
418. Measurement of Personality (3)
420. (Ling. 420) Advanced Psycholinguistics (3)
425. Child Psychology (3)
426. Adolescence (2-3)
430. Verbal Behavior and Verbal Learning (3) *Mr. Cofer*
431. Industrial Psychology (3)
432. Introductory Engineering Psychology (3)
433. Psychology of Occupational Behavior (2)
434. Information-Processing Laboratory (1-6)
436. Mental Health in Schools (3)
437. Psychology of Adjustment (3)
438. Theory of Personality (3) *Mr. Guthrie*
440. Psychology Projects (1-6)
441. Industrial Motivation and Morale (3)
445. (I.F.S. 445) Development Throughout Adulthood (3)
450. (Ed.Psy. 450) Principles of Measurement (3)
452. Laboratory in Sensory Processes (2-4)
453. Neuroanatomy Laboratory (1)
455. Physiological Psychology Laboratory (3)
456. Laboratory in Psychophysiology (2-4)
462. (Biol. 462, Pty.Sc. 462) Animal Behavior—Ethology (3)
463. (Biol. 463, Pty.Sc. 463) Animal Behavior Laboratory (1-2)
474. Psychology of Exceptional Children (3)
482. Introduction to Clinical Psychology (3)

500. Seminar: Introduction to Graduate Study (2-6) Required of all new graduate majors in psychology.

503. Physiological Psychology (2-6) Correlations between structure and function of nervous system and human consciousness; laws and theories in fields of sensation, attention, association, affection, and thought. Prerequisite: 9 credits in psychology.

505. Research Problems in Psychology (1-15) Prerequisite: 12 credits in psychology.

509. Seminar in Conditioning and Learning (3-9) Prerequisite: Psy. 404 or Ed.Psy. 421.

511. Seminar in Contemporary American Psychology (1-9) Critical review of readings on a topic of current interest, either in content or methodology, within psychology. Prerequisite: 9 credits in psychology.

515. Advanced Statistics in Psychology and Education (3) Correlation theory and methods, discriminant function, and factor analysis; applications to mental test theory. Prerequisite: Psy. 415 or Ed.Psy. 506.

516. Seminar in Quantitative Models (3-9)

518. Projects in Experimental Psychology (2-4) Individual experimental projects; seminars on experimental design and instrumentation.

520. (Ling. 520) Seminar in Psycholinguistics (3) The relationship between the behavioral, probabilistic view and the structuralist, deterministic view of language as a system of habits.

527. Statistical Inference and Experimental Design (3) Probability theory, sampling distributions, analysis of variance and covariance, analysis of trend, nonparametric statistics, experimental design. Prerequisite: Psy. 415 or Ed.Psy. 506.

529. (I.F.S. 529) Seminar in Child Development (1-6) Readings and reports on recent findings in child development. Prerequisites: 6 graduate credits in child development, child psychology, or educational psychology, plus 3 in statistics.

Mr. Harris

531. Seminar in Performance Theory (3-9) Topics in theory and research on human performance in perceptual-motor and information-processing tasks. Prerequisite: Psy. 432.

533. Seminar in Engineering Psychology (2-9) Design and operation of machines, man-machine allocation, the man-machine interface, displays, system-design, decision making, image evaluation, and motor behavior. Prerequisite: Psy. 432.

535. Developmental Psychology (2-3) Developmental principles and concepts applied to psychological processes, with special reference to the experimental literature. Prerequisite: 9 credits in psychology.

536. (I.F.S. 536) Research Methods in Developmental Processes (3) Methodological issues in research on varying stages of development across the individual life-span. Prerequisites: 6 credits in individual development or psychology and a course in statistics.

537. Seminar in Industrial Psychology (1-9) Prerequisite: Psy. 431.

538. Psychology of Personnel Development (3) Industrial training in relation to psychological learning theory and experimental findings. Prerequisite: Psy. 431 or Ed.Psy. 421.

539. Seminar in Motivation and Emotion (3-9) Systematic status of instinct, drive, motive, will, purpose; methodology and results of physiological, experimental, and clinical investigation of basic drives.

540. Seminar in Clinical Problems (1-9) Contemporary psychological theory, research, and methodology in relation to clinical psychology. Prerequisites: Psy. 542, 560.

541. Personality Theory (3-4) Contemporary theories of personality; relevant research. Prerequisite: Psy. 438.

542. Psychopathology (3-4) Theories of pathological behavior with reference to clinical and experimental data. Prerequisite: Psy. 412.

545. Seminar in Verbal Learning and Verbal Behavior (1-9)

549. (I.F.S. 549) Developmental Theory (3) Conceptual frameworks and major contributions to the study of individual development across the life-span. Prerequisite: 6 credits at the 400 level in individual development or psychology.
Mr. Harris

555. Theory and Practicum in Clinical Assessment (3-9) Theoretical issues and research in clinical assessment with special reference to administration and interpretation of testing procedures and clinical interviewing. Prerequisites: Psy. 541 or 542, and a course in measurement.

558. Clinical Child Psychology (3-9) Psychopathology of childhood; theories of etiology; diagnosis and treatment. Prerequisites: Psy. 555, 561.

559. (S.Psy. 559) The Individual Psychological Examination (3) Demonstrations and practice in widely used ability and aptitude tests; psychological report writing. Prerequisites: 15 credits in psychology and a course in measurement.

560. Practicum in Clinical Methods (1-6) Supervised practice in the Psychology Clinic, including assessment, therapy, report writing, and staff participation. Prerequisite: Psy. 555.

561. Clinical Practicum with Children (1-6) Diagnosis and counseling of child-parent problems of learning and adjustment. Prerequisites: Psy. 425, 426, 555.

569. Advanced Theory and Practicum in Counseling and Psychotherapy (3-9) Theoretical issues, research, and practicum experience in psychotherapy.

571. Seminar in Social Psychology (3-9) Historical development of theory and methods; determinants and principles of complex social or interactional behavior; contemporary problems and research.

580. Theory and Construction of Attitude Scales (3) Measurement of social, political, commercial, and industrial attitudes; questionnaire designs. Prerequisite: 3 credits in statistics.

581. Experimental Study of Primate Behavior (3) Taxonomy of contemporary species of primates; ontogeny of learning, perception, and affective behavior; interspecies comparisons of behavior.

582. (Biol. 582, Pty.Sc. 582) Research in Animal Behavior (2-6 per term) Research in special areas of animal behavior involving field or laboratory work.

590. Problems in Clinical Research (1-6) Prerequisite: Psy. 415.

591. Seminar on Teaching Psychology (1-3) Objectives and content of psychology; organization and presentation of material; teaching aids and techniques.

PUBLIC ADMINISTRATION (PUB A)

ROBERT J. MOWITZ
Director of the Institute of Public Administration
208 Social Sciences Building

Degree Conferred: M.P.A.

Graduate Faculty, Senior Members: Professor Mowitz, Associate Professors Petras and Riew.

Graduate Faculty, Associate Members: Associate Professors LaPorte and Westby, Assistant Professor Lee.

All candidates take a core program consisting of six seminars which cover the theoretical, methodological, and technological components of public management science. An additional 12 hours may be elected, permitting the student to focus upon such areas as: general public administration, systems analysis, management information systems, urban systems administration, natural resources administration, human resources administration, or any other related substantive area.

Candidates for admission ordinarily will have at least 12 hours of undergraduate credit in the social sciences. Candidates for the degree may be required to take some courses without graduate credit in order to complete a major designed for their professional needs.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

RECREATION AND PARKS (RC PK)

BETTY VAN DER SMISSEN
Associate Dean for Graduate Study and Research
275 Recreation Building

Degrees Conferred: M.S., M.Ed.

Graduate Faculty, Senior Members: Professors Coombs, Gross, Nelson, Storey, and van der Smissen.

The graduate program is designed to prepare students for administrative, supervisory, research, and teaching positions in public recreation and park systems, in colleges and universities, in voluntary agencies, and in institutions.

The program is oriented to meet the specific needs and research interests of the candidate. Areas of specialization include (1) recreation and park administration, including outdoor recreation planning, (2) recreation program supervision and administration, including recreation for special groups, (3) camping, outdoor education, and outdoor interpretive services, and (4) professional education.

The master's degree may be earned in the major field of recreation and parks. At the doctoral level, the Ph.D. and D.Ed. may be earned with a specialization in recreation and parks within the physical education major. Write for details.

For admission to the graduate program, a bachelor's or master's degree is required in recreation, park administration, or in a related field, e.g., forestry, landscape architecture, sociology, psychology, physical education, education, or fine arts. Students

with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

RECREATION AND PARKS (RC PK)

420. Outdoor Recreation (3)
425. Interpretive Services (3)
430. Outdoor Education (3)
440. Camp Administration (3)
456. Recreation Program Organization (3)
458. Dynamics of Recreation Groups (3)
461. Community Recreation (3)
465. Administration of Recreation and Parks (3)
470. Metropolitan Park Management (3)
475. Therapeutic Recreation in the Community (3)
477. Therapeutic Recreation in the Rehabilitation Setting (3)
496. Special Projects (1-6)

500. (Ph.Ed. 500) Individual Study and Research Projects (1-10) Prerequisite: Rc.Pk. 530.

515. Program Development and Supervision (3) Critical analysis of the individual, political, and societal determinants of recreation programming; demonstration projects; evaluative procedures, research functions in programming. Prerequisite: Rc.Pk. 456.

520. Seminar in Camp Administration (3) Values inherent in the camp experience; critical analysis of philosophical choices and sponsor objectives as influencing program development. Prerequisite: Rc.Pk. 230 or 430.

530. (Ph.Ed. 530) Research Techniques in Health and Physical Education and Recreation (3)

533. Recreation Studies, Surveys, and Appraisals (3) Advanced research procedures related to special recreation and park problems. Prerequisites: Rc.Pk. 530 and 3 credits in statistics.

540. Public Recreation Lands (3) Planning recreation lands; legislation, financing, intergovernmental coordination to acquire and develop open space land, urban recreation and park master plan.

550. Seminar in Recreation and Parks (1-6)

560. Administrative Problems of Recreation and Parks (3) Special problems of recreation and park departments; legal powers and liability; departmental organization, financing, personnel policies, and staff development. Prerequisite: Rc.Pk. 465.

590. Philosophical and Social Bases of Recreation (3) Philosophical and social bases of recreation; analysis of critical issues of recreation for philosophical and social implications.

REGIONAL PLANNING (R PL)

Walter H. Walters
Dean of the College of Arts and Architecture
126 Arts Building

James I. Clark
Program Head for Regional Planning
at the Capitol Campus

Degree Conferred: M.R.P.

The objective of this program is to train competent professional planners aware of the needs of citizens and the programs for sound social, political, economic, and cultural advancement through the enlightened management of all resources. For admission a student should have had at least one course each in sociology or political science; physical geography, geology, or soils; and graphics or cartography, plus college level mathematics or statistics. The program is offered at University Park and at the Capitol Campus in Middletown.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

REGIONAL PLANNING (R PL)

400. Principles of Regional Planning (3-6)
410. Planning Programs (3)
420. Theory and Methodology of Regional Planning (3)
440. Problems in Community and Regional Planning (1-9)

502. Regional Systems Analysis (3-6) Spatial structure of regional and interregional systems. Theories of regional development. Spatial measures of location, density, central tendency and dispersion.

510. Planning Techniques and Analysis I (3) Regional socioeconomic structure, problems, and factors in planning; data collection, analysis, and implications.

520. Planning Techniques and Analysis II (3) Interaction of man and environment; land and water resources in regional planning; environmental factors as planning parameters.

530. Planning Techniques and Analysis III (3) Physical, aesthetic, and cultural design aspects of planning. Cultural value judgments and environmental design.

540. Problems in Regional Planning (1-9) Planned individual projects involving library, laboratory (studio), or field work.

RELIGIOUS STUDIES (RL ST)

LUTHER H. HARSHBARGER, *Head of the Department*
N-431 Burrowes Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty, Senior Members: Professors Harrison and Harshbarger, Associate Professor Fukuyama.

Graduate Faculty, Associate Members: Associate Professors Cherry and Vastyan, Assistant Professor Whitney.

The emphasis of the Graduate Studies Program is on the comprehensive understanding of the various facets of religion in American culture, using a variety of methods for analysis and interpretation. A broad cross-disciplinary scope is encourged in substantive areas with particular emphasis on the development of religious thought and movements and the relationships between religion and society. The student will assume the initiative and major responsibility for shaping his own program with a minimum of formal requirements under the supervision of faculty advisers. He can fulfill the degree requirements by working within the department as well as in cooperation with several other departments with offerings related to the general focus of the program. Studies in world religions provide an appropriate context for a focus on American culture.

The language and communications requirement for the Ph.D. degree may be satisfied by an intermediate knowledge of two foreign languages, by substitution of courses from other designated areas for one of these languages, or by a comprehensive knowledge of one foreign language.

Applications will be evaluated on the basis of the quality of undergraduate, graduate, or professional records, whichever is more appropriate, and on the basis of the candidate's clarity of understanding and interest in the specific emphases of the program as described above. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. Graduate Record Examination scores, letters of recommendation, and a statement of the applicant's career goals and academic interests will be required.

RELIGIOUS STUDIES (RL ST)

402. SEMINAR IN CONTEMPORARY RELIGIOUS THOUGHT (3-6)
408. HINDUISM (3)
409. BUDDHISM (3)
421. CULTURE AND RELIGIOUS REFORM (3)
422. RELIGION AND AMERICAN CULTURE (3-6)
430. RELIGION AND MORALITY (3)
438. (Soc. 438) RELIGION AND URBAN SOCIETY (3)
440. PROBLEMS IN RELIGION (3-6)
461. (Soc. 461) SOCIOLOGY OF RELIGION (3)
470. (Sec.Ed. 470) WESTERN RELIGIOUS LITERATURE FOR SECONDARY SCHOOL TEACHERS (3)
471. (Sec.Ed. 471) EASTERN RELIGIOUS LITERATURE FOR SECONDARY SCHOOL TEACHERS (3)

502. STUDIES IN COMPARATIVE RELIGIONS (3-6) Cross-cultural comparative studies of two or more world religions.

505. Seminar in Asian Religions (3-6) Studies in selected Asian religions.

520. Early and Medieval Western Religion (3-6) Studies in Judaism and Christianity from the first century A.D. to 1500.

523. Religion of the Puritans (3) Religious ideas, institutions and leaders of the Puritan movement in England and America; relation of Puritans to cultural developments.

530. Religion and Society (3-6) Studies of mutual influences and effects of religion and secular phenomena.

RURAL SOCIOLOGY (R SOC)

Lee M. Day
Head of the Department of Agricultural Economics and Rural Sociology
6-A Weaver Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty, Senior Members: Professors Bealer, Brown, and Smith.
Graduate Faculty, Associate Members: Associate Professor Willits, Assistant Professor Coward.

In all programs emphasis is on a comprehensive understanding of the various facets of societal organization pertinent to the rural sector. While scope is encouraged, there are available certain areas of special interest and research: consumer behavior; instigated social change; community structure; human resource development; migration; adolescent behavior; the culture of poverty; the ecology of rurality in industrialized, urbanized society. All students are required to have training in sociological theory, statistics, and research methods.

The language and communications requirement for the Ph.D. degree may be satisfied by either (1) mastering one foreign language or (2) passing three graduate courses outside the major and minor fields having communications value.

The entering student in the master's program should have as prerequisites 3 credits in rural sociology, 3 credits in sociology, and 3 additional credits in either field. If he does not have these prerequisites, he may take them at the University during the early part of his master's program.

Students with a 2.75 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.75 grade-point average may be made for students with special backgrounds, abilities, and interests.

RURAL SOCIOLOGY (R SOC)

401. Special Topics in Rural Sociology (1-6)
402. Consumer Behavior and the Agricultural Industry (3) *Mr. Herrmann*
405. Leadership for Social Change (3) *Mr. Smith*
425. Poverty Analysis: People and Programs (3) *Messrs. Madden and Smith*
444. The Rural Transition in American Society (3) *Mr. Leadley*
452. Rural Organization (3)
459. Rural Social Psychology (3) *Mrs. Willits*

501. Development of Rural Sociology (2) Historical development with emphasis on American rural sociology.

502. Advanced Rural Sociology (3) Structure and functioning of rural society; evaluation of theoretical systems.

510. Rural Migration (2) Rural migration research and theory; application to governmental and community problems.

512. National Farm Organizations (2) National farm organizations as social systems. Prerequisite: R.Soc. 452.

513. Sociology of Consumer Behavior (2) Sociological theory and research pertaining to consumer behavior.

514. Values in Rural Society (2) Values as dynamic forces in rural society.

515. Extension Organization and Methods (2) Agricultural and home economics extension as a social system, with emphasis on techniques of organization and program development.

516. Change in Rural Society (2) Social change in rural society, emphasizing prediction and control of the change process.

551. Rural Sociology Seminar (1-6) Prerequisite: 6 credits in rural sociology, sociology, or psychology.

SANITARY ENGINEERING (S E)

Benjamin A. Whisler
Head of the Department of Civil Engineering
212 Sackett Building

Degrees Conferred: M.S., M.Eng.

Graduate Faculty, Senior Members: Professors Nesbitt and Whisler, Associate Professor McDonnell.

Graduate Faculty, Associate Member: Assistant Professor Unz.

The entering student should be a graduate in engineering from an accredited college of engineering. A student wishing to obtain a Ph.D. degree may major in civil engineering with emphasis on sanitary engineering.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

The following courses offered by the Department of Civil Engineering are appropriate for students majoring in sanitary engineering (course descriptions are given under Civil Engineering): C.E. 451, 452, 462, 465, 471, 472, 551, 564, 571, 572, 573, 574, 575, 576, 577, 579, and 580. Appropriate courses offered by other departments include: Ag. 400; Ag.Ec. 422, 505; Bioch. 401, 402, 425, 436; Biol. 410; Chem. 405; Cmp.Sc. 402; Geol. 452; I.E. 405, 509, 510; M.E. 401, 405, 506, 521; Meteo. 473, 502; Micrb. 400, 417; Nuc.E. 420; Pl.Sc. 419, 578; P.Path. 424; R.Pl. 400, 401, 410, 510, 520.

SCHOOL PSYCHOLOGY (S PSY)

JOSEPH L. FRENCH
Chairman of the Committee on School Psychology
101 Rackley Building

Degrees Conferred: D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors French, Gorlow, Noble, and Rabinowitz; Associate Professor Sabatino.

Graduate Faculty, Associate Member: Associate Professor Snyder.

This interdisciplinary program based on courses in psychology, educational psychology, special education, and related fields is designed to produce dually oriented professionals who are well prepared in both psychology and education. The objective is to develop a psychologist who is interested in and knowledgeable about schools. The school psychologist must utilize his professional skills and his knowledge about children and youth to make contributions which are meaningful to and utilized by teachers. The development of competences needed by a fully qualified school psychologist requires at least the education represented by a doctoral degree. Other areas of study related to school psychology, such as clinical psychology, general educational psychology, counselor education, and child development, are found in other departments of the University.

Practicum facilities include the speech pathology and audiology out-patient service, the Reading Center, the Psychology Clinic, and the Demonstration School for mentally retarded children. Facilities for work with children are available through other departments also.

An undergraduate major in psychology or in education of exceptional children is expected of applicants, but students with fewer than 15 credits in psychology may be admitted with limited deficiencies to be made up concurrently with their graduate studies. Requirements for admission include a minimum junior-senior scholastic average of B and a satisfactory scholastic aptitude rating. Applicants with a master's degree will be required to show more than a minimum success in graduate study, including at least one-third of their graduate credits of "A" quality.

Applicants who are able to present at least a 2.80 average in their junior and senior years (or a master's degree with one-third or more grades of *A* quality); satisfactory recommendations; and scores of 500 or higher on the general sections of the Graduate Record Examination, or a raw score of 58 or higher on the Miller Analogies Test, or a raw score of 35 or higher on the Quantitative Evaluative Device is the group from which new students are selected. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests.

SCHOOL PSYCHOLOGY (S PSY)

500. PROFESSIONAL ISSUES IN SCHOOL PSYCHOLOGY (1-3) Orientation to the field through study of unique problems, current issues, ethical and legal matters, unique cases, and research projects.

504. PRACTICUM IN SCHOOL PSYCHOLOGY (1-6) Clinical experience with children under supervision in a variety of settings requiring service including practice in synthesizing data and observations.

508. INTERNSHIP IN SCHOOL PSYCHOLOGY (1-10) Long-term placement in settings providing work for school psychologists with children, parents, teachers, administrators, and service agencies under supervision.

559. (Psy. 559) The Individual Psychological Examination (3) Demonstrations and practice in widely used ability and aptitude tests; psychological report writing. Prerequisites: 15 credits in psychology and a course in measurement.

SECONDARY EDUCATION (SECED)

Paul W. Bixby
In Charge of Graduate Programs in Secondary Education
168 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors Fagan, Fowler, Heimer, Miller, VanderMeer, and Withall.

Graduate Faculty, Associate Members: Associate Professors Dupuis, Koble, Kozak, Ribble, Searles, and Shemick; Assistant Professors Bell, Szabo, and Welliver.

Graduate degree programs emphasize the advanced preparation of classroom teachers, special supervisory personnel, and curriculum specialists. Candidates for the D.Ed. and Ph.D. degrees with a major in secondary education must meet all the requirements, including residence, described in the earlier sections of this bulletin.

The language and communications requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign languages.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. Also required is a provisional certificate to teach in secondary schools, two letters of recommendation, and scores on the Graduate Record Examination (aptitude and advanced sections). For admission to the D.Ed. program at least 18 credits in education and related psychology are required.

Candidates for the D.Ed. degree with a minor in secondary education must take a minimum of 15 course credits approved in advance by the person in charge of the major in Secondary Education. When course work has been completed more than five years prior to admission to the D.Ed. or when it is transferred from another institution, the chairman of the graduate faculty will determine its suitability for any part or all of the 15 hours required.

Candidates for the M.S. degree with a major in secondary education will fulfill all the requirements for that degree, including a thesis, which are listed previously in this bulletin. Candidates with a minor in secondary education must have 6 credits in education approved by the chairman of the graduate faculty. In general, candidates for the M.Ed. in secondary education must have 18 approved undergraduate credits in education and psychology including practice teaching in an area appropriate to the major, and aptitude for and interest in advanced professional preparation. Applicants are urged to have had at least two years of successful teaching experience before completion of the degree requirements. Although candidates are required to specialize in secondary education, they are encouraged to increase their general education in the social sciences, the behavioral sciences, and the humanistic foundations.

The M.Ed. degree may be earned in those fields outside of secondary education for which a master's degree has been approved, provided such a professional program is appropriate. For example, the M.Ed. degree may be earned with a major in English or geography. These programs require 6 credits in professional education approved in advance by the head of the department or the person responsible for the minor field chosen, e.g., secondary education, agricultural education, etc.

Graduate Record Examination scores on both aptitude and education sections are required of all candidates.

SECONDARY EDUCATION (SECED)

400. Introduction to Research Literature (3)
426. Teaching Mathematics in the Secondary Schools (4)
431. Contemporary Secondary School Mathematics Programs (2)
433. Teaching Social Studies in the Secondary Schools (4)
436. Teaching of Conservation of Natural Resources in the Secondary School (3)
438. Teaching Science in the Secondary Schools (4)
441. Computers and the Teaching of Secondary School Mathematics (3)
451. Secondary Education in America (3)
453. Teaching English in the Secondary Schools (4)
454. Extracurricular Activities in the Junior and Senior High School (2-3)
470. (Rl.St. 470) Western Religious Literature for Secondary School Teachers (3)
471. (Rl.St. 471) Eastern Religious Literature for Secondary School Teachers (3)
472. Measurement of Achievement in the Secondary School (2-3)
490. (Human. 490) Humanities for Teachers (3)
497. Workshop in Selected Studies in Secondary Education (1-6)

510. Internship in Secondary School Teaching (3-6) Internship to take place in schools or educational situations where student is not regularly employed, under supervision of graduate faculty.

526. Research Problems in the Teaching of Mathematics (3) Research techniques and procedures dealing with the study of curriculum, materials, evaluation, teaching, learning, and supervision of mathematics. Prerequisites: Sec.Ed. 426, Ed.Psy. 406, and teaching experience.

532. Supervision of Student Teachers (3) A course in supervision for master teachers, department heads, and college teachers with supervisory responsibilities in teacher education. Prerequisites: teaching experience and 18 credits in education including at least 5 in methods.

533. Research Problems in the Teaching of Social Studies (3) Historical-philosophical bases for the social studies: curriculum development, research findings and techniques, learning resources and promising proposals. Prerequisites: Sec.Ed. 433 and teaching experience.

537. (Biol. 537) Workshop in the Biological Sciences (3) Projects designed for teachers of biology in the secondary schools.

538. Research Problems in Science Teaching (3) Problems and research dealing with curriculum, materials, evaluation, and supervision of science teaching and learning. Prerequisites: Sec.Ed. 438 and teaching experience.

539. Research Problems in the Teaching of English (3) Cooperative study by specialists, teachers, and administrators of problems and research findings in the teaching of English in American schools. Prerequisites: Sec.Ed. 453 and teaching experience.

546. (El.Ed. 546) Seminar on Reading Instruction (3-6) Research procedures and materials in reading readiness, word perception, basic reading skills, vocabulary development, reading in content subjects. Prerequisite: Sec.Ed. 443 or El.Ed. 443.

550. Problems in Modern Secondary Education (3) Historical, psychological, social, and economic factors influencing secondary education. Prerequisite: secondary school teaching.

551. Seminar in Contemporary Issues in the Secondary School Curriculum (2-3) Principles and philosophy of curriculum construction. Each student works out an individual problem in the secondary school curriculum. Prerequisites: 12 credits in education and psychology, and teaching experience.

553. Organization and Administration of the Junior High School (2-3) Problems in reorganization of secondary education, with particular reference to philosophy, organization, and teaching problems of the junior high school. Prerequisites: 12 credits in education and psychology, and teaching experience.

585. Curriculum Construction (2-3) Functions of administrators, supervisors, teachers, pupils, and laymen in curriculum building to meet pupil and community needs.

588. Problems, Projects, and Area Studies in Secondary Education (1-6) Independent work in the study of topics in secondary education or the development of new curriculums, materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of the department head.

594. Seminar in Secondary Education (1-3) Conferences and discussions designed to meet the need for special study of particular fields in secondary education. Prerequisite: 12 credits of graduate work in education.

SLAVIC LANGUAGES AND LITERATURES (S L L)

William R. Schmalstieg
Head of the Department of Slavic Languages
N-440 Burrowes Building

Degree Conferred: M.A.

Graduate Faculty, Senior Members: Professors Magner and Schmalstieg, Associate Professor Birkenmayer.

Graduate Faculty, Associate Member: Associate Professor Paternost.

Opportunities for specialization in literature or linguistics are available. A minimum requirement for admission is an undergraduate major in Russian or its equilvalent.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

The department prefers that M.A. candidates in this major submit a term paper rather than a thesis.

RUSSIAN (RUS)

426. Dostoevsky (3)
427. Tolstoy (3)
430. Methods and Materials for Teaching Russian (3)

450. History of the Russian Language (3)
460. Linguistic Analysis of Contemporary Russian (3)
497. Problems in Russian (3-9)

*1G. Technical Russian for Graduate Students (3) Prepares student to translate technical and scientific texts. No previous knowledge of Russian is required.
*2G. Russian Texts (3) Development of skill in translating Russian texts in the sciences and social sciences. Prerequisite: Rus. 5 or 1G.

501. Readings in Russian Literature (3-6) Prerequisite: Rus. 204.

525. Pushkin (3) Pushkin's significance in Russian literature; his relation to other European literatures; *Eugene Onegin* and selected shorter works.

540. Seminar in Old Russian Literature (3) Literary and linguistic analysis of Russian literary monuments in the original, 1100-1800. Prerequisite: Rus. 450.

542. Seminar in Soviet Literature (3-6) Works of representative Soviet writers; individual research in contemporary Soviet literature and literary criticism.

570. Seminar in the Analysis of Old Russian Literary Documents (3-6) Reading, translation, interpretation, and analysis of old Russian literary documents. Texts differ from those read in Rus. 540. Prerequisite: Slav. 550.

SLAVIC (SLAV)

500. Bibliography and Research Techniques (3) Tools and methods of research, designed for students preparing to do independent investigation of problems in Slavic languages and literature.

510. Structure of the South Slavic Languages (3-12; 3 credits per language) Linguistic analysis of a particular South Slavic language (Bulgarian, Macedonian, Serbo-Croatian, Slovenian). Comparative study of all the South Slavic languages. Prerequisite: Rus. 460 or one graduate course in linguistics.

550. Old Church Slavic (3) Reading and study of that corpus of religious and liturgical documents representing the first written records of a Slavic tongue.

560. Theory and Technique in Slavic Linguistics (3-6) Analysis of the relationship of the Slavic languages; consideration of particular linguistic problems within one or more of the languages.

SOCIAL STUDIES (SO ST)

Hugo A. Meier
Chairman of the Committee on Social Studies
214 Sparks Building

Degree Conferred: M.Ed.

This program, designed to meet the needs of secondary school teachers, requires at least 24 credits chosen from economics, history, human geography, political science, and sociology. A candidate is expected to complete at least 3 credits each in four of these areas but not more than 12 in any one of them. A minor of at least 6 credits in educational foundations is also required.

* No graduate credit is given for this course.

For admission a student must have had solid preparation in the basic courses in economics, history, political science, and sociology and should have had some advanced undergraduate work in at least one of these areas. He must also have had 18 credits in education and related psychology, and he should be certified for teaching social studies. Ideally, he should have had teaching experience in this field as well.

Sudents who present a 2.50 junior-senior average and a 3.00 average in the social studies areas will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

SOCIOLOGY (SOC)

DONALD P. KENT, *Head of the Department*
107 Burrowes Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty, Senior Members: Professors Buck, Clark, Kent, Matson, Sherif, Simirenko, and Theodorson; Associate Professors DeJong and Snyder.

Graduate Faculty, Associate Members: Professor Foreman; Associate Professors Faulkner, Raphael, Sim, and Westby; Assistant Professor Rath.

The M.A. and Ph.D. programs center around a training in basic social theory and methodology and the empirical findings in the various areas of sociology. Departmental emphases include social psychology, sociological theory, social gerontology, community structure and change, and an interdisciplinary program in population issues. Other areas in which it is possible for students to specialize include complex organizations, political sociology, the sociology of education, the sociology of religion, the family, and methodology and statistics. The program is designed with considerable flexibility so that students can adapt course work outside the department to their individual interests and goals. Work in computer science, philosophy of science, or mathematics may be used to fulfill part of the Ph.D. degree language and communications requirement, but a reading knowledge of a minimum of one foreign language is required. All first-year students who intend to pursue doctoral work are expected to earn an M.A. degree in their normal progress to the Ph.D. Exceptions may be granted by the departmental Graduate Faculty.

Undergraduate training in sociology is expected. Students of ability who are deficient in undergraduate preparation may be accepted with provisions to make up course deficiencies in the early part of their graduate program. Candidate selection is based on the following information: quality undergraduate academic performance, above average Graduate Record Examination scores, letters of recommendation, and an essay giving the applicant's interests, goals, and purposes for graduate work in sociology. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

The population issues program is a course of study focusing on the social, economic, and geographic policy-related issues arising from the dynamics of population trends, especially in developed nations. In addition to departmental admission requirements, the population issues committee evaluates the student's interest and aptitude for the training program which consists of a minimum of 21 credits of interdisciplinary course work in population.

Other areas of study related to sociology, such as rural sociology, community development, cultural anthropology, developmental psychology, and political behavior are offered in other departments of the University.

Special departmental research and training facilities include the Psycho-Social Studies Center, Medical Sociology Research Center, The Liberal Arts Data Laboratory, small groups research laboratory, and a sociology reference library. Additional University facilities used by sociology faculty and graduate students include the Computation Center, the Inter-University Consortium of Political Research, the Institute of Public Administration, the Institute for Research in Human Resources, and the Center for the Study of Religion and Human Resources.

SOCIOLOGY (SOC)

400. Advanced General Sociology (3)
401. Social Institutions (3)
403. Advanced Social Psychology (3)
404. Small Groups (3)
406. Sociological Analysis of Deviance (3)
408. Social Ecology (3)
410. Social Psychology of Health (3)
412. Penology (3)
413. Methods and Techniques of Social Research (3)
415. The Urban Community (3)
416. (C.F.Ed. 416) Sociology of Education (3)
418. The Development of Social Thought (3)
419. Race Relations (3)
422. History of Sociological Theory (3)
423. Social Demography (3)
424. Social Change (3)
426. Public Welfare Policy and Services (3)
427. Social Case Work (3)
428. Seminar in Sociology (1-6)
429. Social Stratification (3)
430. Family in Cross-Cultural Perspective (3)
432. Collective Behavior (3)
435. Social Gerontology (3)
436. (Journ. 436) Sociology of Opinion Formation (3)
438. (Rl.St. 438) Religion and Urban Society (3)
444. Complex Organizations (3)
446. Political Sociology (3)
450. Community Organization (3)
453. (Anthy. 453) Primitive Religion (3)
454. (L.S. 454) Industry and the Community (3)
455. (L.S. 455) Occupations and Professions (3)
456. Readings in Sociology (1-9)
457. (L.S. 457) Field Work in Industrial Sociology (1-6)
461. (Rl.St. 461) Sociology of Religion (3)
470. Intermediate Social Statistics (4)
473. Methods of Demographic Analysis (3-6)
499. Foreign Study in Sociology (2-6)

500. Seminar in Group Theory (1-3) The group as a unit of social structure and action.

502. Theories of Society (3) Past and present theories of the overall structure and processes of societal functioning.

503. Research Seminar in Social Psychology (3-6) Design and conduct of research in areas of mutual interest in social psychology.

504-505. Current Social Theory (3 each) Current contributions to social theory; their relations to each other and to the larger theoretical structure.

506. Seminar in Sociological Theory (3-9)

507. Introduction to Graduate Study in Sociology (1) Required of all incoming graduate students in sociology.

509. Seminar in Medical Sociology Research (1-6) Early and current classics of medical sociology research critically reviewed; limitations and possibilities; needs of society; available resources. Prerequisites: Soc. 410, 413.

510. Field Work in Sociology (1-6)

511. Readings in the Sociology of Health (1-6) Independent pursuit of existing knowledge in fields of the student's interest, in reference books, monographs, journals. Bibliography preparation. Prerequisite: Soc. 410.

512. Seminar in Deviant Behavior (2-6) Advanced sociological study of crime, juvenile delinquency, mental disorders, suicide, drug addiction, prostitution, and other social deviation. Prerequisite: 6 credits in sociology.

513-514. Sociological Methods (3 each) Critical review of methodological issues; philosophy of science; research designs; analysis and interpretation of findings. Prerequisites: Soc. 413, 470.

515. Seminar in Community Studies (3)

518. Research Studies in the Sociology of Education (3) Analyses of the design, methods, and findings of selected classical and current research studies in the sociology of education. Prerequisite: Soc. 416.

523. Seminar in Population Theory (1-6) Critical review of population theory and research with emphasis on the sociological aspects of demographic behavior. Prerequisite: 3 credits in population or human ecology.

525. Seminar in Sociology (1-6) Research problems in theoretical and applied sociology.

529. Seminar in Intergroup Relations (3) Review of research into minority-majority group relations.

530. Research on Marriage and the Family (3) Training in methods and techniques of research in family relations. Experimental, statistical, and comparative studies are carried out, individually or cooperatively. Prerequisite: 3 credits of previous work in this field.

532-533-534. Social Relations (3 each) Critical appraisal of major social-psychological problems confronting modern man; emphasis on formulation of fruitful research projects and their evaluation. Prerequisite: 15 graduate credits in social science departments or psychology, including a course in statistics.

535. Seminar in Gerontology (2-6) A structural-functional analysis of current research dealing with the relationships between institutional structure, age grading, and social behavior.

*546. Seminar in Political Sociology (3-6) Research and analysis of contemporary issues in political sociology. Prerequisite: 3 credits in statistics.

* 3 credits per term.

555. Industrial Sociology (3) Research methods and techniques in industrial sociology; current research, unexplored areas.

572-573. Social Statistics (3 each) Application of parametric and non-parametric statistical methods to sociology; sampling; computer data processing techniques. Prerequisites: Soc. 470 and 3 credits in research methods.

574-575. Quantitative Sociology (3 each) Problems and issues in the mathematical and quantitative aspects of sociology. Prerequisites: Soc. 413, 470.

SOLID STATE SCIENCE (S S S)

Laxman N. Mulay
In Charge of Graduate Programs in Solid State Science
101 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Barsch, Brindley, Cross, Henisch, Kline, Muan, Mulay, Newnham, Roy, Vedam, and Walker; Associate Professors Dachille, Knox, McKinstry, Stubican, Vastola, E. White, W. White, and Mrs. Roy.
Graduate Faculty, Associate Member: Assistant Professor Johnson.

This program is one of the options in which a graduate student in the Department of Materials Science can receive an advanced degree. The aim of this program is to provide an opportunity for the student interested in the structure, properties, and behavior of solid materials to obtain an integrated program of courses encompassing both the necessary fundamentals of chemistry, physics, and mathematics and their technological and engineering applications.

The program of courses taken by a student majoring in this field must necessarily cut across two or more disciplines. The relevant subject matter has been grouped into four areas: (1) the structure of solids (crystal chemistry and structure determination); (2) theory related to the solid state (physics, chemistry, and mechanics); (3) properties of solids (optical, electrical, magnetic, mechanical, thermal, and chemical); and (4) reactions of solids (phase equilibria, reaction mechanisms, reaction kinetics, and surface reactions).

The course work of all students will normally include the "core program" as periodically redefined by the committee. Recommended course sequences for each year for students with different undergraduate backgrounds are prepared by the chairman and are available form the student's adviser. The language and communications requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages or by one foreign language together with courses from other designated areas.

Entering students should hold a bachelor's degree in chemistry, physics, mathematics, geological science, engineering, ceramics, or metallurgy, or in a closely related field that will have included in it mathematics at least through integral calculus and a minimum of one year of physics and one year of chemistry. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. The applicant should be interested specifically in an interdisciplinary program of study and research. Thesis research on various aspects of the solid state may be conducted in the Materials Science Department and other appropriate departments in the Colleges of Earth and Mineral Sciences, Engineering, and Science;

in the Materials Research Laboratory; and in the Ordnance Research Laboratory. The experimental facilities for research in several aspects of materials science and engineering are exceptional.

S.S.S. 500 (seminar) and S.S.S. 590 (special research problems) will be offered to promote the interdisciplinary aspects of solid state science. Further information will be available from the S.S.S. office.

In addition to the departmental courses, students may select appropriate course work from any engineering or science department. The following list includes those which are most commonly taken to satisfy the requirements; descriptions may be found under the appropriate department headings. Structure of Solids: Chem. 516; Gchem. 512; Min. 463, 500; Mn.Sc. 421, 510, 513. Solid State Theory: Chem. 544, 545, 565, 566, 567; E.Mch. 507, 516, 531, 540; Metal. 514; Phys. 410, 412, 470, 512-513, 517, 561-562, 571. Physical Properties of Solids: Cer.Sc. 506, 507, 508; Chem. 455; E.Mch. 414, 506, 530, 533, 546; Metal. 516; Nuc.E. 509. Chemical Reactions in Solids: Cer.Sc. 503, 504, 511, 512; Chem. 563; F.Sc. 506, 515; Gchem. 513, 520; Mat.Sc. 411A, 411B, 411C, 411D, 420, 421, 512, 514, 516; Metal. 508, 515, 518, 522; Min. 531, 532, 533, 535, 538, 540, 542, 550, 552, 590; Plm.Sc. 406, 407, 408, 409, 410, 560, 562.

SOLID STATE SCIENCE (S S S)

500. Seminar in Solid State Science (1 per term) Topics from current research depicting various aspects of the solid state.

590. Research Problems in Solid State Science (1-4) Specialized theoretical and/or experimental techniques related to research topics in solid state science.

SPANISH (SPAN)

Martin S. Stabb
Head of the Department of Spanish, Italian, and Portuguese
352 Burrowes Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty, Senior Members: Professors Moser, Pérez, Stabb, and Sturcken; Associate Professors Brentin, Dalbor, and Lima.

Graduate Faculty, Associate Members: Associate Professors Halsey, Lyday, and Triolo.

The minimum requirement for admission will normally be 24 credits of post-intermediate work in Spanish language and literature. A student may specialize in either the area of literature or descriptive and historical linguistics. The department may waive the requirement of a thesis for M.A. candidates in this major.

The language and communications requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages or by comprehensive knowledge of one.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

SPANISH (SPAN)

400. Advanced Composition and Conversation (3)
404. The Evolution of Spanish (3)

413. The Teaching of Spanish (4)
414. Spanish Phonology (3)
415. Spanish Morphology and Syntax (3)
416. Old Spanish Literature (3)
426. The Golden Age (3)
427. Drama of the Golden Age (3)
439. Don Quijote (3)
459. The Generation of 1898 (3)
472. The Contemporary Spanish-American Novel (3)
475. Introduction to Latin-American Literature (3)
476. Introduction to Latin-American Literature (3)
477. The Literature of Mexico (3)
480. Literature of Argentina (3)
482. Spanish Lyric Poetry (3)
483. Spanish Drama of the Nineteenth Century (3)
485. Spanish Drama of the Twentieth Century (3)
487. The Spanish Novel of the Nineteenth Century (3)
489. The Spanish Novel of the Twentieth Century (3)
497. Problems in Hispanic Literature (3-12)
499. Foreign Study in Spanish (3)

502. Theory and Techniques of Teaching Spanish (1-3) Audio-lingual orientation. *Mr. Dalbor*

503. Methods and Bibliography in Spanish (1-3) Methods of research; evaluation of sources and materials. *Mr. Brentin*

505. Old Spanish: Phonology, Morphology, and Syntax (3) *Mr. Sturcken*

506. History of the Spanish Language (3) *Mr. Sturcken*

507. Hispano-Romance Linguistics (3) *Mr. Sturcken*

510. Spanish Descriptive Linguistics: Phonology (3) *Mr. Dalbor*

511. Spanish Transformational-Generative Linguistics (3) *Mr. Dalbor*

514. Hispanic Dialectology (3) Early fragmentation among the peninsular dialects; origins and descriptive analysis of the American dialects; Judeo-Spanish. *Messrs. Sturcken and Dalbor*

515. Medieval Spanish Nonepic Literature (3) *Mr. Sturcken*

516. Medieval Spanish Epic Poetry and Prose (3) The *Poema de Mio Cid;* origins and diffusion of epic themes; their influence through the *crónicas,* the *Romancero,* and later literature. *Mr. Sturcken*

518. El Libro De Buen Amor (3) *Mr. Sturcken*

521. The Celestina and the Literature of the Spanish Pre-Renaissance (3) Chief trends and works of the period of the Catholic Monarchs with special emphasis on Fernando de Rojas' masterpiece *La Celestina. Messrs. Triolo and Pérez*

525. Spanish Renaissance and Golden Age Poetry (3) Lyric poetry, epic poetry, and balladry. *Mr. Triolo*

527. Sixteenth-Century Spanish Prose (3) The major prose writers of the Spanish sixteenth century. *Messrs. Brentin and Pérez*

528. Seventeenth-Century Spanish Prose (3) Various types of novels of the

seventeenth century, with special emphasis on the picaresque, didactic literature, histories. *Messrs. Brentin and Pérez*

538. Theatre of Lope De Vega and His Cycle (3) Major works of Lope de Vega, Tirso de Molina, Buillen de Castro, Mira de Amescua, and others. *Mr. Pérez*

539. Theatre of Calderón De La Barca and His Cycle (3) Major works of Calderón de la Barca, Rojas Zorrilla, Augustin Moreto, and others. *Mr. Pérez*

540. Cervantes: The Quijote (3) A careful reading of Cervantes' famous novel and consideration of some of the corpus of criticism on the novel. *Messrs. Pérez and Brentin*

541. Cervantes: Other Works (3) Cervantes' major works, excluding the *Quijote.* *Messrs. Brentin and Pérez*

544. Spanish Romanticism (3) The major authors and works of peninsular romanticism, including poetry, drama and prose. *Miss Halsey and Mr. Lima*

550. Spanish Realism (3) The major figures of the period with special emphasis on Pérez Galdós.

554. Generation of 1898: Prose (3) Selected essays and novels from the works of Ganivet, Pidal, Unamuno, Maeztu, Azorin, Lanza, Baroja and Valle-Inclán. *Mr. Lima*

555. Generation of 1898: Poetry and Drama (3) Selected poems and plays from the works of Antonio and Manuel Machado, Benavente, Grau, Azorin, Valle-Inclán, Unamuno, Baroja and others. *Mr. Lima*

560. The Contemporary Novel in Spain (3) The novel since 1941: Cela, Laforet, Zunzunegui, Suárez Carreño, Matute, and others.

563. Contemporary Drama in Spain (3) The drama since 1898 to the present day: Benavente, Valle-Inclán, Garcia Lorca, Casona, Buero Vallejo, Sastre, and others. *Miss Halsey and Mr. Lima*

566. Contemporary Spanish Poetry (3) Various currents in Spanish poetry from the Generation of 1927: Lorca, Aleixandre, Salinas, Guillen, Alonso, Alberti, Hernandez, Otero and others. *Mr. Brentin*

570. Modernismo (3) The movement, its antecedents, and its followers, with special emphasis on Rubén Darío. *Mr. Moser*

572. Spanish-American Novel of the Nineteenth and Early Twentieth Century (3) Evolution of the genre and representative works. *Messrs. Stabb and Lyday*

573. The Contemporary Spanish-American Novel (3) Evolution of the genre since 1940 and representative novelists. *Mr. Stabb*

575. The Spanish-American Essay (3) Tracing the history of ideas in Spanish America through major essayists. *Messrs. Stabb and Moser*

576. Twentieth-Century Spanish-American Poetry (3) Influential poets and literary movements after *Modernismo.* *Messrs. Lyday and Stabb*

577. Spanish American Drama (3) Dramatic literature in Spanish America from colonial times to the present. *Mr. Lyday*

579. Colonial Literature (3) Transplantation of European culture to Spanish America, literary genres cultivated in the colonies, and principal writers. *Mr. Moser*

581. The Spanish-American Short Story (3) Critical analysis of the major writers and movements from Echeverría to the present. *Messrs. Stabb and Lyday*

584. Spanish American Romanticism (3) The principal writers and tendencies of the Romantic movement in Spanish America. *Mr. Moser*

588. Seminar in Hispanic Literature (3-12) Common and individual research in special problems in Spanish or Spanish-American literature. *Staff*

590. Stylistics and Literary Criticism (3) Major theories of literary criticism applied to Hispanic literature. *Staff*

SPEECH (SPCH)

Herman Cohen, *Head of the Department*
305 Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty, Senior Members: Professors Arnold, Brubaker, Cohen, Holtzman, Nelson, Paulson, Phillips, Schug, and White; Associate Professors Borden, Fife, Frandsen, and Gregg.

Graduate Faculty, Associate Members: Associate Professors Dunham, Hungerford, and Preston; Assistant Professor Butt.

The student may specialize in speech arts (interpretation, drama, theatre); radio and television; rhetoric and public address (including discussion, communication, teaching of speech); speech science (voice, diction, phonetics, general semantics); communicative theory; or international communication. A thesis is required of all M.A. candidates in this major.

The language and communications requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign languages.

The minimum undergraduate preparation required is 12 credits in speech. Students who cannot meet this requirement in full may be admitted but must make up their deficiencies without credit toward the graduate degree. Spch. 400 and 502 are required of all graduate students who do not have their equivalents.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

SPEECH (SPCH)

400. Teaching of Speech (3) *Mr. Schug*
402. Speech and Human Behavior (3) *Mr. Phillips*
410. English Phonetics and Pronunciation (3) *Mr. Brubaker*
412. Speech Criticism (3) *Mr. Arnold*
417. Directing Forensics (3) *Mrs. Lutz*
419. (Journ. 419) Comparative Broadcasting Systems (3)
425. Radio Programming and Performance (3) *Miss Preston*
431. Anatomy and Physiology of the Ear and Vocal Mechanisms (3) *Mr. Gilbert*
435. Radio and Television Programming (3) *Mr. Nelson*

437. Television Programming and Performance (3) *Mr. Hungerford*
440. Speech-Communication: Research and Theory (3) *Mr. Frandsen*
450. Discussion: Research and Theory (2-6) *Messrs. Butt and Phillips*
460. Oriental Rhetoric (3)
461. Contemporary Public Address in the Far East (3)
470. Nonverbal Communication (3)
475. Studies in Mass Persuasion in the Democratic Society (3) *Mr. Hager*
477. Contemporary Public Address: The Great Dictators (2)
478. Contemporary Public Address: English and American Speakers (2) *Mr. Gregg*
480. Computer Applications in Speech Studies (3) *Mr. Borden*
485. Advanced Oral Interpretation of Literature (3) *Mr. Wigley*
489. Directed Study (1-6) *Staff*
490. Psychology of Speaking and Listening (3) *Mr. Holtzman*
494. Teaching of English as a Second Language (3) *Mr. Holtzman*
496. Speech for Teachers (3) *Mr. Butt*

500. Seminar in American Oratory (2-6) History of American oratory with application of critical standards to the work of specific orators. *Mr. White*

502. Research Methods in Speech (3) Research design, thesis proposals, and background for research in graduate study. Prerequisite: 6 credits at the 400 or 500 level in speech, clinical speech, or theatre arts. *Mr. Frandsen*

505. Historical Development of Speech Theory and Criticism (2-4) Classical theories of speech-making from the earliest beginnings to the fall of the Roman Empire. *Mr. Arnold*

506. Historical Development of Speech Theory and Criticism (2-4) Theories of speech-making from the Renaissance to the present. *Mr. Arnold*

508. Seminar in British Oratory (2-4) History of British oratory; application of critical standards to the work of selected orators. *Miss Fife*

509. Problems in Rhetoric and Oratory (2-6) Comparative study of selected orators and rhetoricians. Prerequisite: 6 credits in speech. *Mr. Gregg*

510. Problems in Speech Education (2-4) Advanced knowledge, theories, and principles, together with their philosophical, scientific, clinical, artistic, and educational implications for the teacher of speech. Prerequisite: Spch. 502 and 9 additional credits at the 400 or 500 level in speech, clinical speech, or theatre arts. *Mr. Phillips*

520. Seminar in Speech Science (3-6) Seminar in physical and physiological bases of speech and voice; introduction to laboratory techniques used in speech research. Prerequisite: 9 credits in speech, speech pathology and audiology, or psychology. *Mr. Brubaker*

540. Seminar in Problems of Television and Radio (2-4) Study and research in television and radio as they pertain to programming, production, relation to society, and speech. *Mr. Nelson*

550. Seminar in Oral Persuasion (2-4) Theory and devices of persuasion; analysis of persuasive discourse. Prerequisite: 6 credits in speech including Spch. 200. *Messrs. Holtzman and Frandsen*

552. Oral Communication in Industry, Business, and Government (2-4) Needs, practices, and methods in American industry, business, and government; methods of training adults in oral communications skills. *Staff*

554. Seminar in Small Group Communication (2-4) Communication variables in small groups. Experimental research and innovations in communication in vocational, therapeutic, and educational groups. *Mr. Phillips*

555. Speech Communication: Problems and Principles (2-6) Prevalent theories of speech influence. *Messrs. Borden, Phillips, and Frandsen*

564. Seminar in European Oratory (2-4) Analysis of significant European speeches with consideration of cultural influences on invention and style. Prerequisite: 6 credits in speech. *Staff*

575. Research Problems in Speech (1-9) Advanced research on an individual basis in oratorical criticism, discussion techniques, persuasion, pedagogy, phonetics, speech science, and speech pathology. Prerequisite: 12 credits in speech or speech pathology and audiology. *Staff*

SPEECH PATHOLOGY AND AUDIOLOGY (S P A)

Bruce M. Siegenthaler
In Charge of Graduate Programs in Speech Pathology and Audiology
110 Psychology Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors McDonald, Michael, and Siegenthaler; Associate Professor Frick.

Graduate Faculty, Associate Member: Associate Professor Berlin.

Students may specialize in speech pathology, audiology, or education of the deaf. The programs include the requirement of a number of field trips to diagnostic and treatment facilities and may include a period of internship at an off-campus location. Students should expect to have moderate expenses related to these trips.

The language and communications requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign languages.

Required are 24 credits distributed among speech pathology, audiology, speech science, psychology, and related areas (including one statistics course, tests and measurements for education of the deaf) and letters of recommendations. The no-thesis option is available for the M.S. degree.

Students with a 3.00 (2.50 for education of the deaf) junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the grade-point average may be made for students with special backgrounds, abilities, and interests.

SPEECH PATHOLOGY AND AUDIOLOGY (S P A)

430. Introduction to Audiology (3)
433. Methods in Auditory Training and Speech Reading (3)
434. Pure Tone Audiometry (3)
439. Practicum in Auditory Training and Speech Reading (1-5)
440. (E.E.C. 440) Survey of Speech and Hearing Disorders (3)
441. Current Problems in Speech Pathology and Audiology (1-6)
442. Speech Pathology: Articulation and Stuttering (3)

444. Speech Pathology: Voice and Organic Disorders (3)
445. Professional Programs and Relationships (3)
449. Practicum in Speech Therapy (1-6)
460-461. Teaching Speech to the Deaf (2 each)
462-463. Teaching Language to the Deaf (3 each)
464-465. Teaching Elementary School Subjects to the Deaf (2 each)
466. Problems in Education and Guidance of the Deaf (3)
467. Audiology for Teachers of the Deaf (3)
469. Student Teaching with the Deaf (3-12)

530. Seminar in Audiology (1-6) Review of theories of hearing and review of related physiological and psychological researches. Prerequisite: S.P.A. 434.

531. Speech Audiometry and Hearing Aids (3) Techniques and interpretation of speech reception tests; hearing aids and hearing aid advisement procedures; observations and practice in test administration. Prerequisite: S.P.A. 434.

532. Acoustical Instruments for Hearing (3) Acoustical instrumentation used for research in hearing, programs of hearing conservation, and noise control, including clinical and industrial applications. Prerequisite: 6 credits in acoustics, audiology, experimental psychology, or speech science at 400 level.

534. Noise and Hearing (3) Noise induced hearing problems; interference with communication; annoyance and community problems caused by acoustic energy; regulations and standards. Prerequisite: 6 credits at 400 level in acoustics, audiology, experimental psychology, or speech science.

538. Practicum in Audiologic Evaluation and Selection of Hearing Aids (1-5) Prerequisite: S.P.A. 531.

540. Articulation Disabilities (3) Speech-sound production disorders in children and adults; methods of examination, diagnosis, and treatment. Prerequisites: S.P.A. 442, 449.

541. The Voice and Its Disorders (3) Physical, physiological, and psychological bases of voice production; causes, nature, and symptoms of its disorders; current clinical methods in voice improvement. Prerequisites: S.P.A. 444, 449.

542. Stuttering (3) Modern theories of causes of disorders of rhythm; methods of examination, diagnosis, and treatment. Prerequisites: S.P.A. 442, 449.

543. Diagnostic Procedures in Clinical Speech (3) Clinical instrumentation; case history taking; examination procedures and materials used in diagnosing speech disabilities; interpretation of findings; report preparation. Prerequisite: S.P.A. 444.

544. Cleft Palate (3) Anatomy, physiology, embryology, and growth of the palate and contiguous structures; etiology, diagnosis, habilitation of cleft palate problems. Prerequisite: S.P.A. 444.

545. (E.E.C. 545) Cerebral Palsy (3) Etiology and symptomatology of cerebral palsies; diagnosis and treatment of communication problems; the multi-professional habilitative program. Prerequisite: S.P.A. 444.

546. Language Disorders in Adults (3) Nature, etiology, diagnosis, and management of language disorders in adults. Prerequisite: 9 credits S.P.A. or related fields such as psychology, linguistics, or human development.

547. (E.E.C. 547) Language Disorders in Children (2) Nature, etiology, diagnosis, and management of language disorders in children. Prerequisite: 9 credits

in speech pathology and audiology or related fields such as psychology, linguistics, or human development.

548. Practicum in Speech Diagnosis (1-3) Supervised practice in interviewing, counseling, speech evaluation, and synthesis of psychological medical and audiological data in speech diagnosis; report writing. Prerequisites: S.P.A. 444, 449.

549. Advanced Practicum in Speech Therapy (1-6) Theoretical and clincial rationale of therapy; professional role and relationships; therapy procedures, individual and group; evaluation of process and outcomes. Prerequisites: S.P.A. 442, 449.

550. Seminar in Speech Pathology (1-6) Advanced study of special problems and new developments in speech pathology. Prerequisites: S.P.A. 442, 444.

560. Recent Developments in Education of the Deaf (2-6) In-depth seminar style study of communication disorders associated with deafness, and advanced and experimental attempts at remediation. Prerequisites: 8 credits in education of the deaf or audiology, S.P.A. 430 and 433, and 3 credits in child development or learning theory.

STATISTICS (STAT)

William L. Harkness, *Head of the Department*
333 McAllister Building

Degrees Conferred: Ph.D., M.A., M.S.

Graduate Faculty, Senior Members: Professors Antle, Bartoo, Haight, Harkness, and Patil; Associate Professor Hultquist.

Graduate Faculty, Associate Members: Assistant Professors Boswell and Hettmansperger.

The modern science of mathematical statistics is concerned with the general principles of dealing with uncertainty and partial ignorance. Of fundamental importance to the discipline is the theory of probability, which is the study of mathematical models of random phenomena. Basic courses in statistics and probability are offered regularly.

For the M.A. degree, the candidate must complete 30 course credits, with at least 18 credits (15 in statistics) of 500-level courses, Math. 421, and Math. 441 or 481 in addition to a term paper. For the M.S. degree, 12 credits of 500-level statistics courses, 6-9 credits of thesis, Math. 421, and Math. 441 or 481 are required.

Ph.D. candidacy is contingent upon passing three written qualifying examinations. The language and communications requirement for the Ph.D. degree are flexible, depending on the individual's program, and provide an option of two foreign languages or one foreign language and computer science.

While applications from all students (including those who already have done graduate work) are reviewed, completion of a standard calculus sequence is regarded as a prerequisite. Students with a 3.00 or better junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

STATISTICS (STAT)

401. Experimental Methods I (3)

402. Experimental Methods II (3)
403. Experimental Methods III (3)
409-410. (Math. 409-410) Introduction to Mathematical Statistics (3 each)
412. (Math. 412) Introduction to Mathematical Statistics (3)
418. (A.M. 418, Math. 418) Discrete Probability Theory (3)
427. (Math. 427) Discrete Stochastic Models (3)
451. Statistical Methods I (3)
452. Statistical Methods II (3)
462. Applied Regression Analysis (3)
463. Applied Multivariate Analysis (3)
490. Special Topics in Probability and Statistics (3-9)

501. Multivariate Distribution Theory (3) Sufficiency and completeness, testing hypotheses, sequential analysis, chi-square tests, analysis of variance. Prerequisite: Stat. 410.

502-503. Analysis of Variance and Regression (3 each) Linear hypotheses, regression, analysis of variance and covariance, mixed and random effects models, multiple comparisons, designs. Prerequisites: Stat. 410; Math. 441 or 481.

504. Nonparametric Statistics (3) Goodness-of-fit tests, contingency tables, analysis of multinomial and percentage data, multi-sample problems, special topics. Prerequisite: Stat. 410.

505. Multivariate Statistical Analysis (3) Statistical procedures associated with the multivariate normal distribution. Prerequisites: Stat. 410; Math. 441 or 481.

506. Sampling Theory (3) Theory and application of sampling from finite populations. Prerequisite: 6 credits in statistics.

507. Sequential Analysis (3) A thorough discussion of sequential procedures of estimation and testing of hypotheses. Prerequisite: Stat. 554.

508. Characterization of Statistical Models (3) Characteristics of different statistical distributions; characterizations of distributions through structural properties and statistical procedures. Prerequisites: Stat. 518, 543.

509. Discrete Statistical Models and Methods (3) Systematic study of probability models and statistical methods pertaining to statistical analysis of data consisting of single and multiple counts. Prerequisite: Stat. 554.

512-513. (A.M. 512-513) Introduction to Stochastic Processes (3 each) Markov chains, random walk and recurrent events, queuing theory, time-dependent stochastic processes. Prerequisite: Stat. 418.

517-518. (Math. 517-518) Probability Theory (3 each) Measure theoretic foundation of probability, distribution functions and laws, types of convergence, central limit problem, conditional probability, special topics. Prerequisites: Math. 452, 501.

524. Ecometrics (3) Stochastic models and statistical methods in ecological problems; population dynamics, spatial patterns in populations of one, two or more species. Prerequisite: Stat. 409 or 418.

528. Queuing Models in Transportation (3) Arrival patterns, the service mechanism, queue discipline, delays, multiple queues, problems involving interrupted flow, multiflow routes.

542-543. (Math. 542-543) Statistical Distribution Theory (3 each) Random variables and expectations; discrete, continuous, univariate, multivariate, exact, and asymptotic distribution theory. Prerequisites: Math. 421 and 441 or 481.

553. Statistical Estimation and Testing I (3) Point estimation of one parameter; sufficiency; completeness; maximum likelihood; interval estimation. Prerequisite: Stat. 543.

554. Statistical Estimation and Testing II (3) Neyman-Pearson theory and lemma; uniformly most powerful tests; unbiased tests; large sample procedures. Prerequisite: Stat. 553.

558-559. (Math. 558-559) Theory of Stochastic Processes (3 each) Stationary, independent, and orthogonal processes, discrete and continuous Markov processes, martingales and semi-martingales applications. Prerequisite: Stat. 518.

561. Statistical Inference I (3) Multiparameter estimation; linear estimation; maximum likelihood estimation; Bayesian estimation; large sample properties and procedures. Prerequisite: Stat. 554.

562. Statistical Inference II (3) Testing statistical composite hypotheses; invariance principles; Bayesian statistics; large sample properties and procedures. Prerequisite: Stat. 561.

572. Statistical Decision Theory I (3) Structure of statistical games; optimal strategies, fixed sample-size games. Prerequisites: Math. 502, Stat. 561.

573. Statistical Decision Theory II (3) Sufficient statistics; the invariance principle; estimation and testing. Prerequisite: Stat. 572.

577. (Math. 577) Special Topics in Probability (3-12) Special topics in probability which are not offered regularly but which are of special interest to faculty and students.

590. Seminar in Statistical Methods (1-6) Lectures on current statistical methods; presentation and discussion of literature treating various special topics in statistics.

591. (Math. 591) Seminar in Probability Theory (1-6) Lectures on current and recent research in various special topics in probability theory.

592. Special Topics in Statistics (3-12) Special topics in statistics which are not offered regularly but which are of special interest to faculty and students.

THEATRE ARTS (THEA)

Douglas N. Cook, *Head of the Department*
103 Arts Building

Degrees Conferred: M.A., M.F.A.

Graduate Faculty, Senior Members: Professors Reifsneider, Smith, Walters, and Yeaton; Associate Professor Manfull.

Graduate Faculty, Associate Members: Professor Cook, Associate Professor Allison, Assistant Professor Wells.

The M.A. program is planned to provide breadth of studies in theatre. A thesis in some area of specialization is required.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the mini-

mum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Requirements for admission to the M.A. program are:

1. A broad undergraduate preparation in theatre, including courses in basic acting, directing, theatre crafts, and theatre history (or their equivalents as indicated by evidence or practical experience in the theatre).
2. Eighteen credits in related subject areas, such as oral interpretation, dramatic literature, music, and art.

The M.F.A. program is planned to provide a professional emphasis. Specialization in the following areas is stressed: performance (acting or directing); production (scene design, costuming, lighting, or technical direction); or playwriting. A required final project in the area of specialization includes a monograph.

Requirements for admission to the M.F.A. program are:

1. Twenty-four credits in theatre arts, including one course each in acting, directing, and theatre crafts. Related courses in the student's area of specialization may be accepted.
2. All students are to submit evidence of ability in their areas of specialization under arrangements to be made with the department. Auditions, prompt books, portfolios, manuscripts, and other appropriate presentations are to be submitted by applicants to the various study programs.
3. Vitae and letters of recommendation (at least three) are to be submitted.
4. Personal interviews should be arranged by all students.

All students in the M.A. and M.F.A. programs who are deficient in the required undergraduate courses may be requested to take additional course work in the areas of deficiency without degree credit.

Under certain circumstances the Ph.D. degree is offered by the Department of English with specialization in drama and minor work in theatre arts.

All graduate majors are required to participate in University Theatre productions in positions of responsibility.

401. History of Ancient and Medieval Theatre (3)
402. History of Renaissance and Oriental Theatre (3)
403. History of Modern European and British Theatre (3)
405. History of American Theatre (3)
410. Creative Dramatics with Children (3)
411. Projects in Creative Dramatics (2)
416. Children's Theatre (3)
417. Staging Theatre for Children (3)
418. Marionettes and Puppetry (3)
424. Dance for the Theatre (3)
425. Dance for the Contemporary Musical Theatre (2-6)
427. Theatre Makeup (2)
429. Theatre Performance Practicum (1-6)
434. Directing (3)
435. Rehearsal Methods for the Director (3)
436. Central Staging (3)
445. Advanced Playwriting (3-6)
450. Advanced Scene Design (3-6)
460. Costume Design (3)
461. Costume Construction (3)
462. Drafting Historical Costumes for the Stage (2)
474. Stage Lighting (3)
479. Stage and Production Management (3)
485. Sound for Theatre Production (3)
489. Theatre Production Practicum (1-3)
490. Motion Picture Techniques (3-6)
491. The European Film (3)

492. The American Film (3)
495. Performance for the Camera (3)
496. Radio and Television Directing (3)

500. Theatre Research: Sources and Procedure (1) Materials and techniques as applied to theatre research; the form and content of theses and monographs.

503. Theatre Criticism and Theory (3)

505. Theatre History (3) Specific aspects of theatre from ancient times to the present.

522. Acting I (4) Interpretation of theatrical styles: the tradition of tragedy; voice and movement.

523. Acting II (4) Interpretation of theatrical styles: the tradition of comedy; voice and movement. Prerequisite: Thea. 522.

524. Acting III (4) Interpretation of theatrical styles: forms of modern realism; voice and movement. Prerequisite: Thea. 523.

525. Acting and Directing Theory (3) The actor and director as related to cultural environment from the Greek theatre through the post-Stanislavskian theorists.

530. Play Interpretation for the Director (3) Theory and practice in the analysis and implementation of story, style, and form.

531. Special Forms in Directing (3) Applied theory and techniques for various genres and periods of drama. Prerequisite: Thea. 530.

533. Projects in Directing (1-6 per term)

535. Experimental Theatre (1-3) Operational research and experimental methods in the preparation, planning, execution, observation, and evaluation of production.

540. Playwriting (3-6) Focus on problems in writing the full-length script through seminar, play reading, and individual session.

543. Projects in Playwriting (1-9) Preparation of the script for revision during and rewriting following production of the student's original play. Prerequisite: production approval.

553. Design and Technical Production (1-6 per term) Special projects in design and technical execution of scenery, costumes, lighting, sound, and special effects.

560. Costume Design (3-6) Design concepts, rendering, and execution of costumes for the stage.

574. Lighting for Theatre Production (3) Design techniques for production in arena, thrust, and proscenium theatre situations.

580. Theatre Technology (3) Design consultation and specification of equipment, systems, and movable structures for new theatres; structures and projection devices for production.

582. Theatre Administration (3) The theatre: organization and management.

583. Projects in Theatre Administration, Management, and Operations (1-6)

585. Theatre Planning (3) Processes and problems in planning and designing

theatres: performance, audience, and technical requirements.

590. Special Problems in Film and TV (1-3 per term)

VETERINARY SCIENCE (V SC)

Alfred L. Bortree, *Head of the Department*
115D Animal Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Bortree, Dunne, and Gentry; Associate Professors Glantz and Rothenbacher.

Graduate Faculty, Associate Members: Professor Swope, Associate Professor Zarkower, Assistant Professors Eberhart and Scholz.

Areas of specialization include veterinary pathology, veterinary physiology, and veterinary microbiology. There is opportunity for cooperative research with other departments in animal science, microbiology, and physiology. Unless excused by specific departmental action, all doctoral candidates must attain the master's degree as a step toward candidacy for the Ph.D. degree. A thesis is required of all candidates for the M.S. degree.

The language and communications requirement for the Ph.D. degree may be satisfied by proficiency in reading one foreign language. In the case of foreign students whose native language is other than English, this requirement may be waived with the approval of the doctoral committee.

Prerequisites for admission are a veterinary degree or a bachelor's degree in a related biological field. Adequate preparation in the basic sciences compatible with the candidate's objectives is required. Students may be admitted with limited deficiencies and are required to remove undergraduate deficiencies without degree credit.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. Academic records of candidates with the Doctor of Veterinary Medicine degree or M.S. degree will be reviewed and acted on by the graduate faculty of the department.

VETERINARY SCIENCE (V SC)

401. Ecology of Animal Disease (3) — *Mr. Kradel*
405. Laboratory Animal Science (3) — *Mr. Murphy*
418. Methods of Animal Cell Culture (3) — *Mr. Patton*
420. General Animal Pathology (3) — *Mr. Dunne*

520. Histopathology (3) Specific microscopic alterations and reactions developing in the living animal body when exposed to injurious agents or deprivations. *Mr. Rothenbacher*

525. Mechanisms of Hypersensitivity and Immunopathology (3) Concepts of hypersensitivity and special consideration of immunopathological conditions. Prerequisites: Biol. 437, Micrb. 410, and 3 credits of pathology. *Mr. Zarkower*

528. Diagnostic Pathology (3-9) Gross examination of animals and birds, their tissues and body fluids for pathologic changes. Prerequisites: 6 credits in pathology, microbiology, or infectious diseases.

535. Acquired and Congenital Disorders of Metabolism (3) Abnormalities and alterations in metabolism due to dysfunctions of animal organs. Prerequisites: 6 credits in general biochemistry and 3 credits in animal physiology. *Mr. Scholz*

581. Seminar in Veterinary Science (1-4) Presentation and critical discussion of results of personal research or topics of current interest.

582. Special Problems (1-9) Investigation of special disease problems, including laboratory and field studies.

VOCATIONAL INDUSTRIAL EDUCATION (VI ED)

Joseph T. Impellitteri
In Charge of Graduate Programs in Vocational Industrial Education
242 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professor Brandon, Associate Professor Impellitteri.
Graduate Faculty, Associate Members: Professor Williams, Associate Professors Brantner and Gillie, Assistant Professor Finch.

Emphasis may be placed upon preparation for teaching, supervision, administration, research, or teacher education. The primary focus of the program is preparation for entry into responsible positions within the broadly conceived field of vocational education.

The language and communications requirement for the Ph.D. degree may be met by the successful completion of selected courses in statistics and computer programming.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

INDUSTRIAL EDUCATION (I ED)

402v. Supervision of Vocational Education (3)
403v. Supervised Field Work (6)
408v. Occupations (3)
409v. Tests and Measurements (3)
412v. Special Problems in Vocational Education (6)
415v. Problems in Coordinating Vocational Education (3)
420v. Occupational Hygiene (3)
427v. Advanced Course of Study Building (3)
446v. Improvement of Instruction in Vocational Education (4)
450v. Shop Layout and Management (3)

501v. Seminar in Vocational Education (6) Conferences, investigations, and discussion for advanced students and mature persons who have had experience as teachers, supervisors, or administrators.

506v. Administration of Vocational Education (3) The job of the local director of industrial education in organizing and developing city and other local pro-

grams of industrial education. Prerequisite: 6 credits in industrial education, valid director's certificate, or equivalent training and experience.

510v. Vocational Education for Administrators (3) Designed for school administrators and supervisors who desire an understanding of practical arts and vocational education. Prerequisite: I.Ed. 1v or trade or teaching experience.

550v. Research in Vocational Education (3) Research techniques in vocational industrial education.

556v. Federal Legislation (2-3) Recent federal legislative activities and executive orders that bear directly and indirectly upon industrial education.

557v. Present-Day Local, Personnel, and Curriculum Problems (2-3) Various plans, techniques, and practices.

558v. State and Local Supervision and Administration (2-3) The more important recent problems in organization, supervision, and administration.

559v. Vocational Technical Education (2-3) Problems of organization and administration of programs of technical education at the secondary and post-secondary levels. Prerequisite: 6 credits in industrial education, valid director's certificate, or equivalent training and experience.

560v. Philosophy of Industrial Education (3) Principles and beliefs of progressive industrial education; literature for evaluating instructional practices. Prerequisite: 12 credits in industrial education or teaching experience.

WILDLIFE MANAGEMENT (W L M)

Wilber W. Ward, *Director of the School of Forest Resources*
101 Ferguson Building

Degree Conferred: M.S.

Programs are designed to prepare students for positions in wildlife research and management. Specialized training may be directed toward animal ecology, nutrition, physiology, behavior, or pathology.

Applicants should present a minimum of 12 credits in mathematics including at least 6 credits in statistics and/or computer science, 15 credits in chemistry and physics, and 33 credits in biological sciences including courses in forestry or wildlife. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

WILDLIFE (WILDL)

408. Mammalogy (3)
446. Wildlife Ecology (3)
447. Wildlife Management (3)
492. Field Research Techniques (3)
493. Laboratory Research Techniques (2)
497. Problems in Wildlife (1-3)

590. Wildlife Seminar (1) Discussion of current research and management practices, hypotheses and theories; review of current literature.

597. Research Topics (1-6) Critical analysis of literature or original research on a special topic; written presentation.

ZOOLOGY (ZOOL)

Joseph G. O'Mara, *Head of the Department of Biology*
208 Life Sciences I Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Anthony, Cheng, Cooper, Dalton, and Hale; Associate Professors Bellis, Butler, Dunson, Hibbard, Hymer, and Wickersham; Assistant Professor Henshaw.

Graduate Faculty, Associate Members: Associate Professor Wood, Assistant Professors Abplanalp and Neff.

Zoological programs are offered in animal behavior, cell biology, developmental biology, ecology, endocrinology, fishery biology, genetics, histology, ichthyology, invertebrate zoology, morphology, physiology, or population dynamics.

The language and communications requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

The bachelor's program must show emphasis on zoological subjects and include adequate preparation in mathematics and physical sciences. Each applicant must provide Graduate Record Examination scores, letters from two persons most familiar with his academic qualifications, and a personal statement of his primary interests and objectives.

A limited deficiency may be made up without degree credit while pursuing graduate work. Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests.

See also Genetics and Physiology.

Note: *For courses in Zoology and related subjects see Biology.*

OTHER ELECTIVE GRADUATE COURSES

The following courses are in fields in which neither major nor minor work is offered at this institution. The courses, however, carry graduate credit and, with the approval of the major department, may be applied toward the requirements for a degree either as elective courses or as a part of a general studies program. The usual restrictions upon the use of 400 series courses in degree programs apply to these courses.

AGRICULTURE, GENERAL (AG)

400. Introductory Biometry (3) *Mr. Bennett*

AMERICAN STUDIES (AM ST)

402. Seminar in American Studies (3-9)

501. Theory and Methods of American Studies (3) Theory and methods for the analysis of American culture: history of ideas, analysis of myth and symbol, comparative arts, etc.

502. Problems in American Studies (3-6) A variable-content course, addressed each term to a specific problem, topic, or period in American culture.

ANIMAL SCIENCE (AN SC)

422. Quantitative Inheritance and Animal Breeding (3)
455. Animal Genetics (2)

APPLIED MATHEMATICS (A M)

405. (Math. 405) Fourier Series and Partial Differential Equations (3)
417. (Math. 417) Tensor Analysis (3)
418. (Math. 418, Stat. 418) Discrete Probability Theory (3)
419. (Phys. 419) Theoretical Mechanics (3)
431. (Math. 431) Ordinary Differential Equations (3)
441. (Math. 441) Matrix Algebra (3)
451. Functions of Several Variables (3)
452. (Math. 452) Functions of a Complex Variable (3)
461. (Phys. 461) Theoretical Mechanics (3)
490. Special Topics (1-12)

510-511. Linear Methods (3 each) Matrices, quadratic forms, ordinary and partial differential equations, integral equations, transforms, Fourier series. Prerequisite or concurrent: A.M. 452.

512-513. (Stat. 512-513) Introduction to Stochastic Processes (3) Markov chains, random walk and recurrent events, queuing theory, time-dependent stochastic processes.

520. Asymptotic Techniques in Differential Equations (3) Asymptotic series; applications to ordinary and singular perturbation problems. Prerequisite: A.M. 511.

540. Magnetohydrodynamics (3) The mathematical description of the interaction of an electrically conducting fluid with electromagnetic fields. Prerequisites: A.M. 511, Phys. 557.

550. (Phys. 550) Applied Group Theory (3) Representations of discrete and

continuous groups, applications to theoretical physics and differential equations, varying emphasis on the specific applications. Prerequisite: A.M. 510.

555. Introduction to Group Representations (3) An introduction to matrices, groups, group representations, characters, and orthogonal functions, with orientation to chemistry and physics.

590. Special Topics (2-12) Various topics according to instructor and students. Prerequisite: second-year graduate standing.

THE ARTS (ARTS)

400. Contemporary Forms in the Arts (3)

BEHAVIORAL SCIENCE (BEHSC)

501. Behavioral Science (4) Integration of bio-psycho-social substrates of behavior, variability in behavior during development, and behavioral correlates with disease and health.

502. Behavioral Science (3) Continued integration of bio-psycho-social substrates with emphasis on adaptation, during development, and behavioral correlates with disease and health.

503. Behavioral Science (3) Continued integration of behavioral substrates with emphasis on personality, emotions, nervous system, stress, behavioral correlates of disease, communication, and society. Prerequisite: Beh.Sc. 502.

511. Medical Statistics and Research Design (2) Use of theoretical and applied statistics in medical research design and in the interpretation of data.

521. Primate Behavior (3) Monkey to man survey of intelligence, learning, social behavior, emotions, growth, and physiology; techniques of primate research.

531. Behavioral and Physiological Correlates of Stress (3) Effects of stress on all physiological processes and role of learning, cognition, personality, and culture in adapting to stress.

535. Nervous Systems and Behavior (3) Synthesis on behavioral science, neurobiology, and physiology with emphasis on integrative functions of peripheral, central, and autonomic nervous systems.

537. Mechanisms of Memory (2) Discussion of physiological mechanisms involved in information storage and retrieval. Experimental design in memory research is emphasized.

540. Seminar (1-6) Critical discussion of current literature and research within the behavioral sciences, emphasizing research design, methods, interpretation, and synthesis.

551. Health, Illness, and Culture (3) A medical sociology seminar devoted to the sociocultural aspects of health and sickness.

555. Behavior Change (3) Review of behavioral science research and theory relevant for behavior change procedures used in medicine.

570. Special Topics (1-6) Original and current literature and research methods in special areas in the behavioral sciences.

590. Research Problems (3-12) Independent work to develop and test creative and original hypotheses.

BIOLOGICAL HEALTH (B H)

403. Child Health Needs and Services (3)

CHINESE (CHNS)

489. Readings in Chinese (1-6)

COMMUNITY DEVELOPMENT (COM D)

401. Socioeconomic Change and the Process of Dislocation (3)
402. Politics, Policy, and Community Action (3)
403. Ideal Communities (3)
404. Interpersonal and Group Processes in Community Change (3)
405. Community Mental Health: An Ecological Approach to Human Services (3)
406. Planning and Evaluating Human Service Programs (3)
407. Community Conflict (4)
417. Identifying Community Power Structures (3)
418. Community Organizing (5)
419. Comparative Community Development (3)

CONSUMER SERVICES AND EQUIPMENT (CS EQ)

403. Lecture-Demonstration Techniques (3)
413. Home Equipment (3)
450. Problems in Household Equipment (1-6)

CONSUMER STUDIES (C S)

416. (I.F.S. 416) Consumer Role of Family (3)
420. Consumer Industries (4)
430. Societal Aspects of Consumer Problems (2)

CULTURAL FOUNDATIONS OF EDUCATION (CF ED)

416. (Soc. 416) Sociology of Education (3)
417. Philosophic Basis of Education (3)
418. History of Education in the United States (2-3)
419. History of Education in Ancient and Medieval Times (3)
420. History of Modern European Education (3)
422. Introduction to Comparative Education (3)
466. Race, Poverty and the Schools (3)

515. Experimentalist Philosophies of Education (2-3) John Dewey's educational philosophy and later formulations by Bode, Kilpatrick, Childs, Brameld, and others. Prerequisite: C.F.Ed. 417 or 6 credits in philosophy.

516. Topical Seminar on School and Society (2-6) An intensive and comprehensive analysis of one selected aspect of the relationship of educational institutions to their societal setting. Prerequisite: C.F.Ed. 416.

517. Existential Philosophy of Education (3) The nature, aim, organization, policy, and process of education examined from the viewpoint of existential philosophy and existential phenomenology. Prerequisite: Cf.Ed. 417 or 6 credits in philosophy at the 400 level or above.

519. Contemporary Philosophies of Education (2-3) Implications for education of various types of Realism, Idealism, Existentialism, and Analytic philosophy. Prerequisite: C.F.Ed. 417 or 6 credits in philosophy.

521. Education in the Latin-American Countries (2-3) Recent educational progress in Central and South America, with special reference to Mexico, Cuba, Puerto Rico, Brazil, Chile, and Argentina. Prerequisite: C.F.Ed. 422 or 6 credits in Latin-American studies.

522. Comparative European Education (2-3) Educational policies and practices in school systems in western and central European nations. Prerequisite: C.F.Ed. 422.

524. Education in Communist Countries (2-3) Educational policies and practices in Soviet Russia and other Communist countries. Prerequisite: C.F.Ed. 422 or 6 credits in Russian or Asian studies.

526. Education in Developing Countries (2-3) Educational problems and trends in selected countries, with particular reference to Africa, the Middle East, and Southeast Asia. Prerequisite: C.F.Ed. 422 or 6 credits in Asian, African, or Latin-American studies.

528. Education in Canada (2-3) Development and organization of education in the Canadian provinces; emphasis on dual systems of Ontario and Quebec. Prerequisite: C.F.Ed. 422.

532. Social Change, Cultural Dynamics, and Education (2-3) The social role of the school in a rapidly changing society. Prerequisite: C.F.Ed. 416.

534. Readings in Philosophy of Education (1-6) Selected philosophic writings—classic, modern, or contemporary—on education. Prerequisite: C.F.Ed. 417 or 6 credits in philosophy.

536. Educational Leaders and Classics (2-3) Selected leaders and their writings, with emphasis on historical-social context, including Quintilian, Erasmus, Comenius, Fénelon, Pestalozzi, and Mann.

592. Seminar in Cultural Foundations of Education (1-9) Conferences and discussions designed to meet the need for special study of particular areas in cultural foundations of education. Prerequisites: 12 credits of graduate work in cultural foundations of education.

ENGINEERING (ENGR)

410. Technology—Its Character, Role and Function (3)
450. Patent Fundamentals (3)

500. Special Topics in Engineering (1-3)

ENGINEERING GRAPHICS (E G)

421. Engineering Graphics for Teachers (3)

ENVIRONMENTAL RESOURCE MANAGEMENT (E R M)

400. Senior Seminar (1)
401. Special Studies (1-4)
410. Pollution of Environmental Systems (3)
411. Legal Aspects of Resource Management (2)
412. Resource Systems Analysis (3)

413. Case Studies in Ecosystem Management (3)

FAMILY AND COMMUNITY MEDICINE (FCMED)

510. Normal Sexual Development (1) The basis, development, and pattern of normal sexual development, with an emphasis on the range of "normal."

515. Economics of Health Care (1) Health costs and various means of meeting them.

527. Community Health Agencies (2) Students individually study community health agencies in depth, sharing experiences in seminars with other participants, agency personnel, and faculty.

HEALTH PLANNING AND ADMINISTRATION (H P A)

410. Principles of Public Health Administration (3)
420. Environmental Health (3-6)
430. Principles of Health Planning (3)
431. Health Planning Methods (3)
432. Health Systems Management (3)
433. Health Systems Theory (3)

HOUSING AND INTERIORS (H I)

410. Textile Design I (3)
411. Textile Design II (3)
412. Textile Design III (3)

HUMAN DEVELOPMENT (H DEV)

400. Special Problems in Human Development (1-6)
401. Professional Issues in Human Development (1-3)
499. Senior Thesis (1-10)

516. Methods of Research in Human Development (1-6) Review of problems and techniques of research in human development.

HUMANITIES (HUMAN)

490. (Sec.Ed. 490) Humanities for Teachers (3)

501. Human Values in Medical Care (2) Analysis of questions, concepts, and ramifications of moral and religious values of health and illness; principles of professional responsibility.

505. Ethics and Human Experimentation (2) An analysis of the ethical, moral, and legal aspects of clinical investigation in medicine.

511. Humanities (2) Selected issues in the history and philosophy of science and their relation to culture.

521. Philosophical Ethics (2) A critical delineation and examination of the conceptual framework of ethics.

525. Philosophy of Science (2) An introduction to the basic concepts of the philosophy of science.

541. Science and American Democracy (2) The development of the sciences and institutions of scientific endeavor from colonial times to the modern era.

570. Special Topics (1-6) Specialized study of selected topics in the humanities.

INSTRUCTIONAL MEDIA (INSTM)

435. Orientation to Instructional Media (2)
436. Production and Utilization of Graphic Stimulus Materials (3)
437. Production of Educational Motion Pictures (3)
443. Television in Education (3)

INTERNATIONAL UNDERSTANDING (INT U)

400. World Affairs and International Understanding (3-6)

ITALIAN (IT)

588. Seminar in Italian Literature (3-12) Common and individual research in special problems. *Mr. Triolo*

LABOR STUDIES (L S)

400. Comparative Industrial Relations Systems (3)
411. Trade Union Administration (3)
413. (Econ. 413) Comparative Labor Movements (3)
414. (Econ. 414) Theories of the Labor Movement (3)
415. Labor Movements in Developing Areas (3)
433. (Pl.Sc. 433) The Law of Labor-Management Relations (3)
435. Labor Relations in the Public Sector (3)
454. (Soc. 454) Industry and the Community (3)
455. (Soc. 455) Occupations and Professions (3)
456. (Hist. 456) History of American Labor (3)
457. (Soc. 457) Field Work in Industrial Society (1-6)
489. Problems in Labor Studies (1-9)

LANDSCAPE ARCHITECTURE (LARCH)

420. Landscape Ecology (3)
425-426. Landscape Construction Problems (3 each)
427. Landscape Construction Problems (2)
434. Urban Park and Recreation Areas (3)
454-455. Landscape Design (3 each)
460-461-462. Advanced Landscape Design (4-8 each)
471. Park Systems (2)
472. Planning and Public Policy (3)
473. Recreation Resource Planning (3)
474. Site Engineering Fundamentals (1)

518. Advanced Problems in Landscape Design (2-12) Selected problems for original investigation in the design, construction, and maintenance of landscape architectural projects.

521. Technical Landscape Architectural Practices (2-12) Specific technical and professional problems in landscape architectural planning and practice. Prerequisites: L.Arch. 462, 471.

LAW ENFORCEMENT AND CORRECTIONS (L E C)

401. Probation, Parole, and Pardons (3)
410. Correctional Counseling Processes (3)
430. Correctional Institutions and Services (3)
470. Law of Crimes and Corrections (3)
480. Research Literature on Crime and Corrections (3)

LIBERAL ARTS (L A)

450. Independent Study (1-9)
460. Undergraduate Internship (1-4)
480. Technological Change and Human Values (3)
489. Undergraduate Seminar: Selected Topics (3-9)

LITHUANIAN (LITH)

500. Structure of Lithuanian (3) Analysis of the phonology, morphology, and syntax of Lithuanian; comparative linguistic study of Balto-Slavic and Indo-European. Prerequisite: one graduate course in linguistics.

MATERIALS SCIENCE (MATSC)

401. Materials Science for Teachers I (3)
402. Materials Science for Teachers II (3)
404. Process Measurement and Control (1)
411. (Min. 411) Instrumental Techniques Applied to Materials and Mineral Science Problems (1-5)
Unit A. X-Ray Diffraction
Unit B. Electron Microscopy
Unit C. Spectroscopy
Unit D. Electron Probe Analysis
Unit E. Scanning Electron Microscopy
416. Materials Preparation (2)
420. Mathematical Modelling for Materials Scientists (3)
421. (Min. 421) X-Ray Diffraction (3)
431. (Min. 431) Instrumentation for Physical Measurement and Control (3)
490. Special Topics in Materials Science (1-9)

500. Materials Research for Teachers (3) Independent research on a problem from materials science. Topic chosen by consultation with the supervising faculty. Written report required. Prerequisite: Mat.Sc. 402.

512. (Gchem. 512) Principles of Crystal Chemistry (2-4) Relation of structure to ionic size and nature; influence of pressure and temperature on structure; chemical-structural defects, crystalline solutions, phase-transitions.

514. Characterization of Materials (3) Classical and new (microprobe, scanning microscope, magnetic resonance, and Mossbauer) techniques for the characterization of composition, structure, defects, and surfaces.

524. (Gchem. 524) Vibrational Spectra of Materials and Minerals (2) Infrared and Raman spectroscopy of solid materials with applications to crystal chemistry, materials characterization and glass research. Prerequisites: Phys. 412, 471.

531. (Min. 531) Electron Transmission Microscopy in the Materials and Mineral Sciences (3) Discussion of electron image contrast theory as a tool for study of atomic substructures in the materials and mineral sciences.

532. (Min. 532) Structure Analysis (2) Crystal structure determination methods: space groups, structure factors, heavy atoms and isomorphous replacement, Fourier synthesis, Patterson maps, inequalities, refinement techniques. Prerequisite: Mat.Sc. (Min.) 421.

533. (Min. 533) Single Crystal Methods (2) Experimental techniques in crystal structure determination: crystal selection, space group determination, measurement of intensities, analysis of data. Prerequisite: Mat.Sc. (Min.) 421.

534. (Min. 534) Diffraction by Crystals (2) Interaction of radiation with matter: coherent and incoherent scattering, extinction, fluorescent, polarization. Prerequisite: Mat.Sc. (Min.) 421.

535. (Min. 535) Geometrical Crystallography (3) Derivation of lattices, types, point groups and space groups with applications.

538. (Min. 538) Electron Beam Analysis of Solids Via X-Ray and Electron Emission (3) Theory of phenomena occurring in electron-bombarded solids and their applications to analysis of solids.

540. Crystal Anisotropy (2) Symmetry aspects of crystals and physical properties. Matrix and tensor methods. Prerequisite: Phys. 412.

542. Magnetic Methods in Materials Science (3) Static magnetic (susceptibility type) and spectroscopic methods (nuclear and electron magnetic resonance, Mossbauer spectroscopy) for materials characterization and structural analysis. Prerequisite: Phys. 413.

550. Evaporation and Condensation of Solids (2) Thermodynamics of evaporation and condensation of solids; condensation processes including thin films and epitaxial growth and their applications.

552. Theory and Practice of Crystal Growth (3) Theoretical approaches to crystal growth and of the various techniques used in growing crystals.

554. Electronic Spectra of Materials (2) Crystallographic and thermodynamic applications of crystal field theory. Electronic spectra of crystals and glasses. Luminescent spectra and phosphor characterization. Prerequisite: Phys. 471.

564. Structure and Properties of Carbons and Graphite (3) Relation of the ideal and defect structure of polycrystalline carbons and graphite to their mechanical, electronic, thermal, and optical properties. Prerequisite: Phys. 412.

570. Catalytic Materials (3) Preparation and characterization of solid catalytic materials. Relationships between their surface, defect, and electronic properties and catalytic activity. Prerequisite: Chem. 452.

590. Special Topics in Materials Science (1-6) Intensive group study of special topics.

MINERAL ENGINEERING (MIN E)

424. (Metal. 424) Coal Preparation (3)

PATHOLOGY (PATH)

501. Principles of Pathology (4) The fundamentals of reaction to injury at cellular and tissue levels emphasizing the pathogenesis of functional, structural, and biochemical abnormalities. Prerequisite: admission to College of Medicine.

502. Principles of Pathology (4) The fundamentals of human disease with emphasis on pathogenesis of functional, structural, and biochemical abnormalities at the organ system level. Prerequisite: admission to College of Medicine.

510. The Clinical Laboratory in Laboratory Medicine (5) Seminars, tutorials, and independent analysis by the student of specific laboratory problems which relate to human disease. Prerequisites: admission to College of Medicine; Path. 501, 502.

513. Applied Surgical Pathology (4) Student will study tissues daily received by the surgical pathology laboratory. Problems encountered in many clinical specialties will be considered. Prerequisites: admission to College of Medicine; Path. 501, 502.

516. Autopsy Pathology (5) Students will first assist and then perform autopsies under supervision. Emphasis will be on correlations with clinical and experimental medicine. Prerequisites: admission to College of Medicine; Path. 501, 502.

520. Biology of Neoplasia (3) Detailed examination of the initiation and pathogenesis of animal neoplasms with emphasis on the relationship to human neoplasia. Prerequisite: admission to College of Medicine.

524. Biological Membranes, Structure and Function (2) Critical consideration of biological membranes emphasizing comparative structure and biochemical composition through small group discussion and review of current literature. Prerequisite: admission to College of Medicine.

530. Tropical Pathology (4) Study of diseases commonly encountered in tropical areas with emphasis on parasites and infectious and nutritional disorders. Prerequisite: admission to College of Medicine; Path. 501, 502.

540. Development of Educational Tools and Methods in Pathology (3) Development of new educational tools and methods to teach pathogenesis of disease to patients, medical students, and medical technology students. Prerequisite: admission to the College of Medicine.

560. Pathology Seminar (1) Staff and student seminar covers current research and educational and service developments in the field. Prerequisite: admission to College of Medicine.

570. Special Topics in Pathology (1-6) Specialized training in advanced research techniques available in the department. Prerequisite: admission to College of Medicine.

590. Research Problems in Pathology (1-12) Individualized research on pathology problems conducted by students in medical school laboratories. Prerequisite: admission to College of Medicine.

PHYSIOLOGY (PHSIO)

520. Medical Physiology (2) Cellular physiology including membrane permeability; bioelectric potentials, muscle contractions, secretion; cardiovascular physiology including hemodynamics, cardiac function and output, peripheral circulations.

521. Medical Physiology (4) Organ and metabolic physiology, including renal, endocrine, neuromuscular, gastrointestinal, and respiratory.

525. General Physiology (2) Cellular processes of accumulation membrane transport, bioelectric potentials, contraction, and secretion in erythrocytes, nerves. sensory receptors, muscles, glands, excretory organs.

PHYSIOLOGY

530. Metabolic and Endocrine Physiology (3) Regulations of carbohydrates, fatty acid and protein metabolism; regulation of hormone secretion; effects of hormones on water and cell metabolism.

550. Seminar (1 per term) Critical appraisal by staff and students of current research developments and of data collected in current investigations.

570. Special Topics (1-6) Training in the use of research techniques; examination in depth of a specialized topic on the level of current research.

590. Research Problems (1-12) Individualized research conducted by students in departmental laboratories.

PLANT SCIENCE (PLTSC)

400. Principles of Plant Science Research (2)
401. Independent Study in Plant Sciences (1-6)

POLISH (POL)

501. Readings in Polish Literature (3-6) Individual reading and research in nineteenth and twentieth century Polish literature and literary criticism.

POLYMER SCIENCE (PLMSC)

406. Introduction to the Materials Science of Polymers (3)
407. Technology and Applications of Polymeric Materials (3)
408. Polymeric Materials Laboratory (1)
409. Introduction to Properties of Polymeric Materials (3)
410. Polymer-Based Composite Materials (3)

560. Properties of Polymeric Materials (3) Macroscopic and microscopic behavior of polymeric materials. Interpretation of properties in terms of structure. Prerequisite: Plm.Sc. 406.

562. Polymeric Materials Characterization Laboratory (2) Characterization of polymeric materials by chemical and physical methods. Prerequisite: Plm.Sc. 406.

POPULATION ISSUES

Qualified students may select Population Issues as an optional area of specialization when majoring either in economics, geography, or sociology. Additional information is given under the description of those majors in the preceding section.

PORTUGUESE (PORT)

588. Seminar in Portuguese and Brazilian Literature (3-12) Common and individual research in special problems. *Mr. Moser*

SAFETY EDUCATION (SAFED)

450. Visual and Other Aids in Safety Education (3)
451. Teaching Traffic Safety and Automobile Operation (3)
452. Organization and Supervision in Safety Education (3)

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1972-1973

The Pennsylvania State University Bulletin

Graduate Degree Programs

1972-1973

THE PENNSYLVANIA STATE UNIVERSITY

GRADUATE DEGREE PROGRAMS

GENERAL CATALOG ISSUE

SEPTEMBER 1972

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GRADUATE CALENDAR*

SUMMER TERM 1972

MAY 1972

27 Saturday—Last Date for a Prospective Graduate Student to Submit Completed Application Materials for Admission to the Summer Term 1972

27 Saturday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Summer Term 1972

JUNE

27, 28 Tuesday and Wednesday—Pre-examinations in German for Advanced Degree Candidates

27, 28 Tuesday and Wednesday—Summer Term Registration

28 Wednesday—Last Date for Registering with Educational Testing Service, Princeton, N. J., for French and Spanish Written Language Examinations

29 Thursday—Summer Term Classes Begin 8:00 A.M.

JULY

4 Tuesday—Independence Day Holiday

7 Friday—Last Date for Registering with Foreign Language Departments (Other than French and Spanish) for Written Language Examinations

17 Monday—Last Date for a September Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office

22 Saturday—Written French and Spanish Language Examinations for Advanced Degree Candidates

22 Saturday—Last Date for a September Graduate to Deliver Doctoral Thesis to Committee

25 Tuesday—Last Date for Written Foreign Language Examinations (Other than French and Spanish) for Advanced Degree Candidates

29 Saturday—Last Date for Final Oral Doctoral Examinations for September Graduates

29 Saturday—Last Date for a September Graduate to Deliver Master's Thesis or Paper to Adviser

AUGUST

14 Monday—Last Date for a September Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Completion of Required Papers

14 Monday—Last Date for a September Graduate to Order Cap, Gown, and Hood Locally

24 Thursday—Eight-Week Summer Term Classes End 9:55 P.M.

SEPTEMBER

2 Saturday A.M.—Last Date for Submitting a Petition to Graduate in Absentia in September

4 Monday—Labor Day Holiday

8 Friday—Ten-Week Summer Term Classes End 9:55 P.M.

11, 12 Monday and Tuesday—Final Examinations

16 Saturday—Commencement

* This calendar was approved on May 1, 1971, and is subject to change without notice. In preparing the calendar for an academic year, the University makes every effort to avoid conflicts with religious holidays. However, such conflicts are sometimes unavoidable. When they occur, efforts are made to make special arrangements for the students affected.

FALL TERM 1972

AUGUST

21 Monday—Last Date for a Prospective Graduate Student to Submit Completed Application Materials for Admission to the Fall Term 1972

21 Monday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Fall Term 1972

SEPTEMBER

20-22 Wednesday to Friday—Pre-examinations in German for Advanced Degree Candidates

20-22 Wednesday to Friday—Fall Term Registration

20 Wednesday—Last Date for Registering with Educational Testing Service, Princeton, N. J., for French and Spanish Written Language Examinations*

25 Monday—Fall Term Classes Begin 8:00 A.M.

29 Friday—Last Date for Registering with Foreign Language Departments (Other than French and Spanish) for Written Language Examinations

OCTOBER

12 Thursday—Last Date for a December Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office

14 Saturday—Written French and Spanish Language Examinations for Advanced Degree Candidates†

17 Tuesday—Last Date for Written Foreign Language Examinations (Other than French and Spanish) for Advanced Degree Candidates

21 Saturday—Last Date for a December Graduate to Deliver Doctoral Thesis to Committee

28 Saturday—Last Date for Final Oral Doctoral Examination for December Graduates

28 Saturday—Last Date for a December Graduate to Deliver Master's Thesis or Paper to Adviser

NOVEMBER

13 Monday—Last Date for a December Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Completion of Required Papers

13 Monday—Last Date for a December Graduate to Order Cap, Gown, and Hood Locally

22-27 Wednesday 12:25 P.M. to Monday 8:00 A.M. —Thanksgiving Day Holiday

DECEMBER

2 Saturday A.M.—Last Date for Submitting a Petition to Graduate in Absentia in December

6 Wednesday—Fall Term Classes End 9:55 P.M.

7-11 Thursday to Monday—Final Examinations

16 Saturday—Commencement

* Registration fee ($10) must accompany registration form, available from 205 Kern Graduate Building. A late registration fee of $3.50 will be charged for registrations received one week late.

† Tests administered by The Pennsylvania State University. Contact Professor A. V. Kozak, 166 Chambers Building.

WINTER TERM 1973

DECEMBER 1972

4 Monday—Last Date for a Prospective Graduate Student to Submit Completed Application Materials

4 Monday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Winter Term 1973

JANUARY 1973

4, 5 Thursday and Friday—Pre-examinations in German for Advanced Degree Candidates

4, 5 Thursday and Friday—Winter Term Registration

8 Monday—Winter Term Classes Begin 8:00 A.M.

10 Wednesday—Last Date for Registering with Educational Testing Service, Princeton, N. J., for French and Spanish Written Language Examinations*

12 Friday—Last Date for Registering with Foreign Language Departments (Other than French and Spanish) for Written Language Examinations

25 Thursday—Last Date for a March Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office

27 Saturday—Last Date for a March Graduate to Deliver Doctoral Thesis to Committee

30 Tuesday—Last Date for Written Foreign Language Examinations (Other than French and Spanish) for Advanced Degree Candidates

FEBRUARY 1973

3 Saturday—Written French and Spanish Language Examinations for Advanced Degree Candidates†

3 Saturday—Last Date for Final Oral Doctoral Examination for March Graduates

3 Saturday—Last Date for a March Graduate to Deliver Master's Thesis or Paper to Adviser

19 Monday—Last Date for a March Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Completion of Required Papers

19 Monday—Last Date for a March Graduate to Order Cap, Gown, and Hood Locally

MARCH

10 Saturday A.M.—Last Date for Submitting a Petition to Graduate in Absentia in March

17 Saturday—Winter Term Classes End 12:25 P.M.

19-22 Monday to Thursday—Final Examinations

24 Saturday—Commencement

* Registration fee ($10) must accompany registration form, available from 205 Kern Graduate Building. A late registration fee of $3.50 will be charged for registrations received one week late.

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SPRING TERM 1973

FEBRUARY

24 Saturday—Last Date for a Prospective Graduate Student to Submit Completed Application Materials for Admission to the Spring Term 1973

24 Saturday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Spring Term 1973

MARCH

21 Wednesday—Last Date for Registering with Educational Testing Service, Princeton, N. J., for French and Spanish Written Language Examinations*

27, 28 Tuesday and Wednesday—Pre-examinations in German for Advanced Degree Candidates

27, 28 Tuesday and Wednesday—Spring Term Registration

29 Thursday—Spring Term Classes Begin 8:00 A.M.

APRIL

6 Friday—Last Date for Registering with Foreign Language Departments (Other than French and Spanish) for Written Language Examinations

14 Saturday—Written French and Spanish Language Examinations for Advanced Degree Candidates†

16 Monday—Last Date for a June Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office

21 Saturday—Last Date for a June Graduate to Deliver Doctoral Thesis to Committee

24 Tuesday—Last Date for Written Foreign Language Examinations (Other than French and Spanish) for Advanced Degree Candidates

28 Saturday—Last Date for Final Oral Doctoral Examination for June Graduates

28 Saturday—Last Date for a June Graduate to Deliver Master's Thesis or Paper to Adviser

MAY

14 Monday—Last Date for a June Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Completion of Required Papers

14 Monday—Last Date for a June Graduate to Order Cap, Gown, and Hood Locally

15 Tuesday—Annual Graduate Faculty Meeting

JUNE

2 Saturday A.M.—Last Date for Submitting a Petition to Graduate in Absentia in June

6 Wednesday—Spring Term Classes End 9:55 P.M.

7-11 Thursday to Monday—Final Examinations

16 Saturday—Commencement

* Registration fee ($10) must accompany registration form, available from 205 Kern Graduate Building. A late registration fee of $3.50 will be charged for registrations received one week late.

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Thomas J. Cook, Jr., Ph.D. (Florida State) *Asst. Prof. of Public Administration*
Wade E. Craighead, Ph.D. (Illinois) *Assistant Professor of Psychology*
Robert M. Davis, Ed.D. (Maryland) *Assistant Professor of Education*
William S. Decker, M.A. (Iowa) *Associate Professor of Marketing*
Phillip Dettra, M.F.A. (Penn State) *Instructor in Music*
John J. Dinkel, Ph.D. (Northwestern) *Assistant Professor of Management Science*
William S. Donaldson, D.Ed. (Virginia) *Assistant Professor of Education*
Aaron Druckman, B.A. (Penn State) *Associate Professor of Philosophy*
William A. Dunn, M.S. (Oklahoma State) *Associate Professor of Engineering*
Richard T. Edelman, B.A. (St. John's) *Associate Professor of Theatre Arts*
John R. Ezzell, Ph.D. (Penn State) *Assistant Professor of Finance*
Frances E. Fairchild, D.Ed. (Missouri) *Assistant Professor of Education*
James L. Farr, Ph.D. (Maryland) *Research Associate in Psychology*
Joanne Z. Feldman, M.S. (Juilliard) *Associate Professor of Music*
Leonard Feldman, M.Mus. (Eastman) *Associate Professor of Music*
Burt L. Fenner, M.A. (Columbia) *Assistant Professor of Music*
Ronald L. Filippelli, Ph.D. (Penn State) *Historical Collections Archivist*
Charles H. Firmin, M.F.A. (Penn State) *Instructor in Theatre Arts*
Charles Forney, Jr., M.S. (Penn State) *Assistant Professor of Computer Science*
James J. Gebhard, Ph.D. (Indiana) *Instructor in Slavic Languages*
Anne A. Gibson, M.F.A. (Carnegie-Mellon) *Associate Professor of Theatre Arts*
Trond Gilberg, Ph.D. (Wisconsin) *Assistant Professor of Political Science*
Harvey R. Gilbert, Ph.D. (Wisconsin) *Assistant Professor of Speech Science*
Stella R. Goldberg, Ed.D. (Columbia) *Assoc. Prof. of Child Dev. and Family Rel.*
Steven L. Goldman, Ph.D. (Boston) *Assistant Professor of Philosophy*
Jon P. Gunnemann, M.A. (Yale) *Assistant Professor of Religious Studies*
Carol Hendrick, M.M. (Yale) *Instructor in Music*
Donald E. Hopkins, M.Mus. (Texas) *Assistant Professor of Music*
Barton L. Jenks, Jr., M.S. (Princeton) P.E. *Assoc. Prof. of Mechanical Eng.*
Ronald W. Johnson, M.A. (S.U.N.Y.) *Asst. Prof. of Public Admin. & Pol. Sci.*
Donald B. Keat II, Ph.D. (Temple) *Assistant Professor of Education*
David P. Kemple, Ph.D. (Pittsburgh) *Assistant Professor of Sociology*
Manfred E. Keune, Ph.D. (Michigan State) *Assistant Professor of German*

Oscar A. Kimmel, M.S. (Penn State) *Associate Professor of Farm Mechanics*
Michael R. King, Ph.D. (Oregon) *Assistant Professor of Political Science*
Edgar H. Knapp, Ed.D. (Columbia) *Associate Professor of English and Education*
William J. Knight, Ph.D. (California) *Assistant Professor of Mathematics*
Alfred E. Kohout, M.F.A. (Wisconsin) *Assistant Professor of Theatre Arts*
Gerald Lang, M.F.A. (Minnesota) *Instructor in Photography*
Glorianne M. Leck, Ph.D. (Wisconsin) *Assistant Professor of Education*
Ernest B. Lowrie, M.A. (Yale) *Assistant Professor of Religious Studies*
David A. MacDonald, Ph.D. (Florida) *Staff Psychologist, Division of Counseling*
Thomas D. Marro, D.Ed. (Colorado State) *Asst. Prof. of Special Education*
Albert K. Mastantuono, Ph.D. (Western Reserve) *Asst. Prof. of Special Ed.*
Francis R. McKenna, Ph.D. (Michigan) *Assistant Professor of Education*
Peter B. Meyer, Ph.D. (Wisconsin) *Asst. Prof. of Economic Planning*
D. Douglas Miller, M.M. (Drake) *Assistant Professor of Music*
P. June Miller, M.Mus. (Yale) *Assistant Professor of Music*
Webb C. Miller, Ph.D. (Washington) *Asst. Prof. of Computer Science*
Frank L. Moreland, Ph.D. (California) *Asst. Prof. of Environmental Planning*
James L. Morrison, Ph.D. (Florida State) *Asst. Prof. of Ed. and Sociology*
Raymond O. Murphy, D.Ed. (Penn State) *Assistant Professor of Education*
M. Eloise Murray, Ph.D. (Penn State) *Asst. Prof. of Home Economics Ed.*
Joan Nessler, Ph.D. (Penn State) *Associate Professor of Physical Education*
William G. Noyes, M.Ed. (Penn State) *Assistant Professor of Music*
Robert E. O'Connor, Ph.D. (North Carolina) *Asst. Prof. of Political Science*
David O. Ongiri, Ed.D. (Minnesota) *Assistant Professor of Education*
Charles P. Orlando, Ph.D. (Connecticut) *Asst. Prof. of Special Ed.*
H. Raymond Page, M.A. (Ohio State) *Assistant Professor of Music*
James H. Patterson, Q.B.A. (Indiana) *Asst. Prof. of Management Science*
Douglas J. Pedersen, Ed.D. (Penn State) *Assistant Professor of Speech*
Harry Perison, M.M. (Eastman) *Assistant Professor of Music*
Dan J. Peterman, Ph.D. (California) *Asst. Prof. of Human Development*
Charles S. Prebish, Ph.D. (Wisconsin) *Assistant Professor of Religious Studies*
Marian A. Quick, M.A. (Smith) *Associate Professor of Deaf Education*
Carl A. Ridley, Jr., Ph.D. (Florida State) *Asst. Prof. of Human Development*
Audrey T. Rodgers, Ph.D. (Penn State) *Assistant Professor of English*
Dante V. Scalzi, D.Ed. (Penn State) *Assistant Professor of Education*
Robert J. Scannell, Ph.D. (Penn State) *Professor of Physical Education*
Gordon M. Shedd, Ph.D. (Penn State) *Assistant Professor of English*
Jane M. Singh, Ed.D. (Arizona State) *Assistant Professor of Education*
A. K. Sinha, Ph.D. (Sheffield) *Assistant Professor of Mining*
Jane I. Smith, Ph.D. (Harvard) *Assistant Professor of Religious Studies*
Ronald A. Smith, Ph.D. (Wisconsin) *Asst. Prof. of Physical Education*
Charles C. Spence, Ph.D. (Michigan State) *Assistant Dean of Student Affairs*
Lloyd M. Sundblad, Ph.D. (Syracuse) *Assistant Professor of Education*
Yoshimitsu Takei, Ph.D. (Florida) *Asst. Prof. of Education and Sociology*
Smith C. Toulson III, M.M. (Yale) *Assistant Professor of Music*
Robert F. Trehy, Diploma (American Theater) *Associate Professor of Music*
W. Bruce Trinkley, M.A. (Columbia) *Instructor in Music*
Richard D. Twark, Ph.D. (Penn State) *Asst. Prof. of Quantitative Business Analysis*
Helen B. Volz, M.S. (Penn State) *Instructor in Speech Pathology*
John D. Walmer, M.D. (Temple) *Adjunct Associate Professor of Education*
Joseph Warren, Ph.D. (Wayne State) *Assistant Professor of Mathematics*
Susan F. Weis, Ph.D. (Penn State) *Asst. Prof. of Home Economics Education*
Charles C. Werberig, M.S. (Syracuse) *Assistant Professor of Theatre Arts*
Joseph A. Wigley, Ph.D. (Northwestern) *Associate Professor of Speech*
Theodore C. Willoughby, Ph.D. (Minnesota) *Asst. Prof. of Bus. Administration*
Vickie L. Ziegler, Ph.D. (Yale) *Assistant Professor of German*

GENERAL INFORMATION

THE GRADUATE SCHOOL

Graduate work at The Pennsylvania State University was first offered in 1862, but for some time there were few graduate students and graduate instruction was relatively unorganized. A committee of the General Faculty eventually was given the responsibility of establishing standards and regulations governing graduate work and the granting of master's and certain technical degrees. The Graduate School was formally established in 1922 by the President and the Board of Trustees. An administrative staff was organized, and the Graduate Faculty was formed. The University Senate delegated to this faculty responsibility for graduate affairs, subject to review. In 1924 the Board of Trustees authorized the granting of the degree of Doctor of Philosophy. On May 9, 1971 a Graduate Council was established for the Graduate School. Today graduate study is offered in 124 major programs, with 14 advanced academic and professional degrees being conferred. During the academic year 1970-1971, 5,000 to 5,500 graduate students were enrolled each term, and 1,823 advanced degrees were conferred, of which 436 were doctorates.

The Graduate School maintains close contact with other graduate schools in order to keep abreast of developments in graduate education throughout the country. It is a member of the Association of Graduate Schools (an organization within the Association of American Universities) and of the Council of Graduate Schools in the United States.

MAJOR ROLE—The major role of the Graduate School is to emphasize those aspects of University activity which pertain directly to major programs in graduate study. Through its Graduate Faculty it represents a large segment of the academic strength of the University and is thus a dominant force in sustaining and furthering the intellectual quality of the entire institution. The eleven colleges formulate study and research programs appropriate to their fields. The Graduate Faculty consists of those members of the college faculties who have authorization through the Graduate School to offer courses and seminars and supervise research and theses consistent with the highest academic standards. Thus the Graduate School may be regarded as a federation of selected segments of the college faculties.

GOVERNANCE—The governance of the Graduate School is vested in a Graduate Council, whose legislative authority is subject to the specific restrictions of the "Articles of Authority." The Council forms its own committee structure under bylaws outlined in "Standing Rules of the University Graduate Council." A summary of actions taken by the Council is published in the *Senate Digest*.

Executive and administrative matters of the Graduate School are the responsibility of the Dean, who is charged directly with enforcement of the regulations of the Graduate School and with organization of its administrative procedures. The Dean has a major responsibility to enhance and insure the high quality of graduate study and research of graduate students on the University Park Campus and at other locations where such graduate work is conducted. He exercises leadership in initiating new programs and in restructuring or phasing out marginal and obsolete ones. The Dean encourages and assists in the development of multidisciplinary programs. He is assisted in this work by an administrative and clerical staff.

ADMINISTRATIVE DIVISIONS—There are four major administrative divisions in the Graduate School to which the students may go directly for answers to the questions which require administrative assistance or decisions:

1. *Graduate Admissions,* 308 Kern Graduate Building. The Office of Graduate Admissions has responsibility for processing all matters pertaining to a student's admission.
2. *Graduate Student Programs,* 211 Kern Graduate Building. The functions of the Office of Graduate Student Programs encompass responsibilities for the academic

involvement and concerns of all graduate students from the time they are admitted until they graduate, such as: (a) registration of students, (b) readmission of students, (c) maintenance of records, (d) appointment of graduate committees for doctoral students, (e) scheduling of graduate student comprehensive examinations, (f) checking for accomplishment by students of Graduate Faculty requirements for all advanced degrees and preparation of official commencement lists, and (g) attention to student academic problems.

3. *Graduate Fellowships,* 317 Kern Graduate Building. The Office of Graduate Fellowships serves as a clearinghouse for information on available fellowships and other awards for graduate students, administers fellowships and other award programs involving students in more than one college, and seeks support for graduate students attending the University.
4. *Theses and Publications,* 320 Kern Graduate Building. The Office of Theses and Publications is responsible for reviewing all theses to meet Graduate School specific requirements consistent with the attainment of high scholarly standards. The Office prepares, arranges for publication, and provides source materials through the major Graduate School publications.

PROGRAMS AT OTHER LOCATIONS

Behrend Graduate Center—The Behrend Graduate Center at Erie opened with the winter term, January 1969, and provides convenient opportunity for graduate education to persons residing in northwestern Pennsylvania. It has been established to offer individual courses and a program leading to the degree of Master of Engineering with a major in engineering science.

King of Prussia Graduate Center—The King of Prussia Graduate Center near Philadelphia opened in 1963. Its programs lead to the degrees of Master of Engineering with a major in engineering science and Master of Education with a major in mathematics.

The Capitol Campus—The Capitol Campus, located near Middletown and named for its proximity to the state capitol, was opened in 1966. Graduate programs leading to the degrees of Master of Administration, Master of Arts with majors in American studies and in humanities, Master of Education with a major in elementary education, Master of Engineering with a major in engineering science, Master of Public Administration, and Master of Regional Planning are currently offered.

The Milton S. Hershey Medical Center—The University's Medical Center was established in 1963, and the first class of medical students entered in the fall of 1967. The Center is located in Hershey, Pennsylvania, twelve miles from Harrisburg. In conjunction with The Pennsylvania State University's Graduate School, the College of Medicine offers programs leading to the Master of Science degree with a major in laboratory animal medicine, and to the Doctor of Philosophy and Master of Science degrees with majors in anatomy, biological chemistry, microbiology, pharmacology, and physiology.

COOPERATIVE ARRANGEMENTS WITH OTHER INSTITUTIONS—A working arrangement has been established with Jefferson Medical College of Philadelphia whereby a candidate for an advanced degree at Jefferson may do part of his graduate work at The Pennsylvania State University by scheduling relevant courses and research at University Park. Similarly, a graduate student with an appropriate major at The Pennsylvania State University may earn credits at Jefferson which, with advance approval by his major department or program, will be accepted in partial fulfillment of degree requirements at The Pennsylvania State University.

KERN GRADUATE BUILDING

The new graduate building opened in February and was officially dedicated on March 16, 1971. It has since been officially named the Kern Graduate Building in honor of Dean Emeritus Frank D. Kern, who was the first Dean of the Graduate School. The Graduate School administrative offices are housed on the second and third floors of the building.

GRADUATE COMMONS—The Graduate Commons is located on the first floor of the Kern Graduate Building and provides facilities for the entire Graduate School community and a common meeting ground for faculty and students. The assembly room and multipurpose rooms are used for large group meetings; the smaller rooms are used for seminars and doctoral oral examinations.

Food service is provided in the cafeteria. The lobby is available for display of art work done by students and faculty. Exhibits are normally displayed for two weeks.

The Office of the Graduate Commons Manager serves as a clearinghouse for the scheduling of events planned by organizations and individuals.

GRADUATE STUDENT ASSOCIATION

The Graduate Student Association was established in 1951 as the official voice of graduate students, all of whom are automatically members. It is the particular function of the organization to give to the individual member the opportunity to stimulate student intellectual interests and to bring to light problems and resolve them through discussion and collective action. It provides the occasion for relaxation through its social program. The University allocates an appropriation to the Association to help defray expenses.

The Association has an Executive Board and Council of Representatives, which consists of elected representatives from every graduate department, with voting rights proportionate to the number of students in any given department, nonvoting *ex officio* representatives from graduate living units, and representatives to committees outside the Graduate Student Association. The council meets regularly to conduct the business of the Association; the Executive Board has interim powers to conduct business not requiring the specific action of the Council of Representatives. The executive officers from the board act as official liaison between the council and the Dean of the Graduate School.

The Association has an office in 305 Kern Graduate Building, where it maintains its records and conducts its business. The Graduate Student Association has established the following standing committees: (1) Housing Committee, (2) Program Committee, (3) Graduate Center Committee, (4) Academic Affairs Committee, (5) Rules Committee, (6) Public Relations Committee, (7) International Student Committee, and (8) Committee on Graduate Intramural Athletics. In addition, the council may institute *ad hoc* committees or presidential commissions at will.

The Association elects four graduate students to serve as full voting members on the University Faculty Senate, and five graduate students as voting members to serve on the Graduate Council. Membership on the Council is for a period of one year. Graduate students are eligible to serve on all committees of the Council.

The Association maintains communications among its members through the campus daily newspaper, its own newsletter, scheduled meetings, and informal use of the Graduate Commons.

FACILITIES

UNIVERSITY LIBRARIES—The libraries at University Park include a central collection and two special libraries, serving the Colleges of Agriculture and Arts and Architecture, in the Fred Lewis Pattee Library; three separate branch libraries, serving the Colleges of Earth and Mineral Sciences, Engineering, and Science; and two reading rooms for the Departments of Architecture and Mathematics. They contain approximately 1,200,000 catalogued volumes, some 600,000 government documents, and more than 1,000,000 other bibliographical items (microforms, maps, manuscripts, audio tapes, etc.).

The central collection includes reference materials in the humanities and social sciences, books, periodicals, newspapers, and microforms in the fields of agriculture, biology, education and psychology, economics and business, the fine arts and humanities, and the natural and social sciences. The branch libraries and reading rooms contain books and journals needed for the subjects studied in those colleges and departments. A number of instructional guides to assist faculty and students in using the facilities are issued by the libraries and may be obtained at service desks. Included among the special resource guides issued by the library is *Newspapers in Microform.*

COMPUTATION CENTER—The Computation Center aids in the education and research programs of all academic departments. Its facilities are open to graduate students and faculty engaged in research and to students doing class assignments. Its equipment includes two large System/360 computers, an Adage AGT-30, a 1401, and several small peripheral machines. The System/360 Model 67 has one million bytes of fast core storage, two million bytes of slower core storage, 600 million bytes of disk and drum storage, and a large configuration of input/output equipment. Access to the Model 67 can be obtained through high-speed batch terminals located on the main campus or through medium-speed batch terminals located at the Commonwealth Campuses. The System/360 Model 50 is about one-half the size of the Model 67 and is devoted to time-sharing services. Several access stations, providing instant turnaround for short jobs, are available for students first learning to use a computer. Typewriter terminals may access to either the Model 50 APL/360 time-sharing system or the Model 67 remote job entry facility using the dial telephone network. A well-equipped ADAGE AGT-30 Computer Graphics System allows extensive graphics work. An interface to the Model 67 further extends its graphics capability. The Computation Center staff conducts workshops to acquaint graduate students and faculty with its services. A student who will need the Center's facilities should attend these workshops and should consult the staff early in his research so that a program can be worked out for his project and his work scheduled without delay. Programming consultants in the Center provide advice and assistance in using library programs prepared by the Center and in programming and checking out new applications. The facilities of the Computation Center are widely used for instruction and research in most academic departments at no charge to the student. The Graduate Centers, the Capitol Campus, and The Milton S. Hershey Medical Center have remote batch terminals which permit processing of computer jobs by the central computer equipment operated by the Computation Center at University Park.

OTHER FACILITIES—The University offers many additional facilities which are available to students through their major programs of study.

PROCEDURES AND REGULATIONS

A student is expected to assume full responsibility for knowing the regulations and pertinent procedures of the Graduate School as set forth in the publications, the *Manual for Graduate Students* and the *Thesis Information Bulletin,* and for meeting

the standards and requirements expressed by these regulations. The *Manual*, which is available to a student after he has been admitted, sets forth in more detail the procedures governing registration, changes in program, and graduation, and gives other information about the Graduate School which is useful to graduate students. Every student should secure a copy from the Office of the Dean soon after admission.

STATEMENT OF NONDISCRIMINATION

In the selection of individuals for graduate study, in which the University has partial or complete control of the selection process and administration of the program, the University will not discriminate on the basis of race, creed, color, sex, or national origin of any applicant.

ADMISSION

An applicant for admission to the Graduate School should understand that graduate work is not a simple extension of an undergraduate program. It operates at a higher level, demands scholarship of a higher order, and emphasizes research, creativity, and professional competence with a minimum of formal requirements and a maximum of student initiative and responsibility.

Applicants must recognize that staff, facilities, and other resources are limited so that not all qualified persons can be admitted. The number accepted will vary by program and from term to term. In some graduate programs all vacancies will have been filled long before the deadline for submitting applications so that even outstanding students cannot be accepted. The objective of the Graduate School is to admit a graduate student body of high qualifications up to the limit of the University's resources to provide graduate programs of outstanding quality. In general, a student may begin his graduate work in fall, winter, spring, or summer.

Students are normally expected to begin work at the University Park Campus unless they have been admitted to an approved graduate program offered at Behrend or King of Prussia Graduate Center or the Capitol Campus. Applicants interested in programs offered at these locations should apply directly to the appropriate campus. Applicants for the University Park Campus or The Milton S. Hershey Medical Center should apply at University Park. Any exception to this policy must be approved jointly by the graduate department head or program chairman and the Office of Graduate Admissions.

For admission to the Graduate School an applicant must have received a baccalaureate degree from an accredited institution, earned under residence and credit conditions substantially equivalent to those required by The Pennsylvania State University. He must ordinarily have completed in a satisfactory manner a certain minimum of course work in designated areas, the specific courses and amount of work depending upon the field of advanced work which the student proposes to enter.

Admission is granted jointly by the Graduate School and the department or graduate program in which the student plans to follow his studies. The establishment of standards by which applicants are admitted is a departmental or program responsibility. Though the Graduate School has no fixed minimum grade-point requirement for admission, an applicant is generally expected to maintain during his junior and senior years quality in his work equivalent to a grade-point average of at least 2.50 on The Pennsylvania State University grading scale of A (4) to D (1). Individual programs may establish higher grade-point averages and other criteria by which they will judge candidates for admission. Departments or major programs may also, in exceptional cases, approve admission by reason of special backgrounds, abilities, and interests. Departmental or program requirements are given in the descriptive statements appearing under the major programs listed in the latter part of this publication.

The above requirements apply particularly to the student who recently completed an undergraduate program and is about to begin graduate study. An applicant who has obtained a graduate degree at a recognized graduate school will be evaluated largely on the basis of the graduate record.

Forms to be used in applying for admission can be obtained from the Office of Graduate Admissions. Applicants may apply for admission to only one program at a time. All academic records, and explanation of the grading system used, should be submitted, *in duplicate,* to the Office of Graduate Admissions, 308 Kern Graduate Building. These must be received from all institutions by the Graduate School at least one month prior to the opening of the term in which the student plans to begin his graduate program. Foreign students should plan on applying at least three months prior to the beginning of the term. Foreign students must submit certified English translations of all academic records.

The deadline for processing of applications by the Graduate School is one month prior to the beginning of a specific term. Graduate major programs may require earlier deadlines. A complete admissions file, which is required for processing an application, includes the following items: (1) application blanks, (2) application fee form, (3) a check or money order in the amount of $15.00 made payable to The Pennsylvania State University, and (4) duplicate transcripts from each institution of higher education attended. This applies to the complete academic record, both undergraduate and graduate. If the admissions file is incomplete a month prior to the beginning of the term for which the student has applied, his materials will be processed for the first term following the completion of his admissions file.

A student with a slight deficiency in undergraduate preparation may be admitted and allowed to take a limited number of undergraduate courses to make up the deficiency while proceeding with his graduate program. Courses taken for this purpose do not, of course, apply toward the requirements of the advanced degree.

Admission may be granted to applicants whose credentials are not complete at the time of application because the baccalaureate degree has not yet been conferred, grades for the current term are not yet available, etc. Such admission is subject to cancellation if the complete credentials, on arrival, do not meet the requirements for admission. In the interim, certification of any earned credits will be withheld. If admission should, for any reason, be canceled, the student is thereby automatically dropped from the Graduate School.

A student who plans to take courses for transfer to another institution or to follow a program of study not leading to an advanced degree at this institution should apply for admission as a nondegree student. The adviser for such a student may be appointed by the department head or program chairman most closely associated with the student's field of interest. The number of nondegree students which can be admitted is limited because preference is given to students in degree programs.

A student who has been admitted to a program in which the doctorate is offered may begin working toward that degree, but he has no official status as a doctoral student and no assurance that he will be accepted as a doctoral candidate until he has passed a candidacy examination administered by his major department or committee.

UNDERGRADUATE STUDENTS—A senior student of The Pennsylvania State University lacking not more than 4 credits for graduation may be admitted to the Graduate School. This limit may be increased to 8 credits in the case of a student with an average of at least B (a grade-point average of 3.00). Any senior with a 3.50 grade-point average may be admitted to 500-level courses with the consent of the instructor; other undergraduate students with a B average or better may be admitted to such courses with the consent of the instructor and the Dean of the Graduate School.

In certain cases undergraduate students may subsequently apply credits they have earned in 400- and 500-series courses toward an advanced degree at The Pennsylvania State University. Upon admission to the Graduate School such credits as are relevant to the graduate program of study and were not used to satisfy undergraduate require-

ments will be entered on the student's graduate transcript. These may then be applied toward an advanced degree provided they are acceptable to the major program and minor field. The time limitation on the completion of a master's degree program applies to these as well as to other credits.

GUESTS OF THE UNIVERSITY—It is the policy of this Graduate School not to permit applicants to work for a second doctoral degree. The President, on recommendation of the Dean of the Graduate School, will welcome as guests holders of earned doctor's degrees who may be visiting the University Park Campus for purposes of noncredit study. Guest privileges apply to persons holding the degree from The Pennsylvania State University or other accredited colleges and universities. Guests may attend seminars and courses and, if space and facilities are available, carry on research. There will be no charge except for laboratory expenses. Arrangements should be made in advance with the Dean of the Graduate School.

STUDENT RESIDENT STATUS—Whenever it appears that an applicant for admission is not domiciled in Pennsylvania, it is assumed that he is a non-Pennsylvanian. If a student who is thus admitted believes that his circumstances do not justify his classification as a non-Pennsylvanian, he may petition the Dean of the Graduate School through the Financial Officer, 316 Kern Graduate Building, for reclassification.

When a petition for reclassification is made, the petitioner is required to present proof of a bona fide continuous domicile (other than as a student) within the Commonwealth for a period of at least 12 months immediately preceding the date of registration for courses, or such other evidence as is pertinent to a complete review of his classification.

Any student who changes his domicile while attending the University is subject to reclassification effective at the beginning of the first term following notification to the Graduate School that such a change has been made.

Registering to vote in Pennsylvania does not in itself affect a student's classification as a non-Pennsylvanian. Tuition reduction entitlement is determined by residence at the time of admission.

CLASSIFICATION OF STUDENTS

A graduate student may be admitted either as a degree student or as a nondegree student, depending upon his objectives. After admission to one of these categories, any change to the other must be arranged through the Office of Graduate Student Programs.

DEGREE STUDENTS—A degree student is one who plans to become a candidate for an advanced degree at The Pennsylvania State University and who has been formally admitted for advanced studies in a particular program. The program of study is developed under the guidance of an adviser appointed by the head of the student's major program. A degree student who has passed a candidacy evaluation is classified as a doctoral candidate.

NONDEGREE STUDENTS—An applicant who meets all requirements for admission to the Graduate School, but who does not wish to work for an advanced degree at this institution, may arrange for a program of work as a nondegree student. This classification includes any who plan to transfer credits to another institution and those who plan special programs of study not leading to an advanced degree. The number of nondegree students who can be admitted is limited, and it is increasingly difficult to provide for them because of the limitation of total enrollment. Preference is given to students in degree programs.

Nondegree students who are applying for admission to the University Park Campus *must* submit two transcripts from each institution attended. Transcripts should be

sent to the Office of Graduate Admissions, 308 Kern Graduate Building, The Pennsylvania State University, University Park, Pa. 16802.

The admission of a nondegree graduate student at the University Park Campus will be subject to the recommendation of the program chairman or head of the department in which he proposes to do most of his work or in which his major interest lies. Casual students with broad interests, not easily identifiable with a single program, may be admitted directly by the Graduate School. Applications and credentials must be received at least one month prior to the anticipated term of enrollment.

ADJUNCT STUDENTS—An adjunct student is not a graduate student, inasmuch as he has not been admitted to the Graduate School, and may not register for graduate courses or research (500 and 600 series) without permission of the Dean of the Graduate School. An adjunct student may register for 400-level courses provided he has attained at least junior standing in college.

Credits earned as an adjunct student may not ordinarily be applied subsequently toward an advanced degree.

PROGRAMS

MAJOR PROGRAM—A student's major program is his field of primary interest and the one in which the greater portion of his work is taken. Programs are designed to prepare the student to assume a position of informed and responsible authority in his field and to contribute creatively to it. They promote not only specialization, but also breadth of scholarship, the ability to study and think independently, and familiarity with the principal techniques and important literature in the field. The research undertaken by the candidate should deal with a problem that is truly significant and represents research at its best.

INTERDISCIPLINARY MAJORS—In addition to the graduate major programs listed in this bulletin, interdisciplinary majors involving two or more departments within a single college or intercollege majors involving two or more colleges may be arranged with the approval of the Dean of the Graduate School. These programs are offered under the supervision of appropriate interdepartmental or intercollege committees.

In general, departments of the University are identified with specific major programs. Thus aerospace engineering is a major program of study which is offered under the supervision of the Department of Aerospace Engineering. On the other hand, engineering acoustics and genetics are major programs for which there are no corresponding departments. In such cases, a committee of the Graduate School is responsible for administering the program. In some cases a single department offers work in more than one program. Thus the Department of Material Sciences offers work in ceramic science, fuel science, and metallurgy.

Applicants for admission are encouraged to consult the person whose name is listed under the major program heading.

MINORITY STUDENTS—Different colleges and departments offer graduate study relating to minority students, and financial assistance is sometimes available. Information may be obtained from the deans of the colleges or through the graduate programs of the students' major interests.

ADVANCED DEGREES OFFERED

The degrees of Doctor of Philosophy and Doctor of Education are conferred by the University. Both require high attainment and productive scholarship, but the Ph.D. places a strong emphasis on research, whereas the D.Ed. emphasizes professional competence in some field of education or teaching.

The Master of Arts and the Master of Science degrees are academic in nature, the programs placing strong emphasis on basic knowledge and research. The professional master's degrees conferred are the Master of Administration, Master of Agriculture, Master of Business Administration, Master of Education, Master of Engineering, Master of Environmental Pollution Control, Master of Fine Arts, Master of Forestry, Master of Public Administration, and Master of Regional Planning.

A candidate for the M.Adm., M.Eng., or M.P.A. degree may meet all the requirements for his degree at a Graduate Center or the Capitol Campus of The Pennsylvania State University provided the major department head or supervising committee and the Dean of the Graduate School have agreed that a complete program of study leading to the specific degree can be pursued at these locations. Thus a complete program leading to the degree of Master of Engineering with a major in engineering science has been approved for the Behrend Graduate Center, the King of Prussia Graduate Center, and the Capitol Campus. Such designation of location of the completion of the program will be noted on the student's transcript.

CHANGE OF DEGREE OR PROGRAM

A graduate student who has been admitted for work in one major program, but wishes to transfer to another, should submit his request to the Office of Graduate Student Programs of the Graduate School. The student's credentials will be reviewed and the proposed new major department head or committee chairman consulted. If the change is approved, the student may be required to make up certain undergraduate deficiencies if he is inadequately prepared for the new major.

A graduate student admitted for either an academic degree (M.A., M.S., or Ph.D.) or a professional degree (M.Adm., M.Agr., M.B.A., M.E.P.C., M.Ed., M.Eng., M.F., M.F.A., M.P.A., M.R.P., or D.Ed.) who wishes to change to another type of degree program must apply to the Office of Graduate Student Programs of the Graduate School for the transfer. Similarly, a student who has earned a master's degree must apply for a formal transfer if he plans to work for a doctor's degree of a different type. A student may be required to make up certain deficiencies if inadequately prepared for the new program.

GRADUATE CREDITS

It is important that the student understand that in the Graduate School the word "credit" has no meaning other than as a unit of time—time spent in residence and in off-campus graduate work. One credit stands for the equivalent of approximately one week of full-time graduate work, and 10 credits for a term's work.

Typically, a candidate for an advanced degree is required to earn a certain minimum number of credits on the University Park Campus. Consequently, there is a limit to the number of credits he may earn elsewhere to meet the minimum requirements of his degree. Moreover, the department or committee in charge of a major program may require a student to do more of his work at University Park Campus than specified by the following limitations set by the Graduate Faculty.

CONTINUING EDUCATION—A large number of courses carrying credit are given throughout the Commonwealth of Pennsylvania by Continuing Education. All 400-series courses so offered carry graduate credit for students who have been admitted to the Graduate School. The adviser's signature is required on the official registration form, which the student submits at the designated place of registration for the course.

There is no limit to the number of graduate credits which a student may earn in Continuing Education, but not more than 10 credits so earned may be applied toward the minimum requirements for an advanced degree.

REGISTRATION

The responsibility for being properly registered rests with the student. At least until his program is near completion, he is expected to register for each term in which he proposes to do either course work or research toward his thesis, whether it be on or off campus. In the case of research, the number of credits shall be determined by the amount of time required for the investigation, one credit representing the equivalent of one week of full-time work. In the later stages of his program the situation will determine the requirements for the student's registration.

ADVISERS—To assist the student in planning his program, the head of his major department or program chairman will designate a member of the faculty to serve as adviser. It is the student's responsibility to secure the name of his adviser from the department head and to seek a conference before registration.

TIME OF REGISTRATION—Registration days are indicated in the calendar at the beginning of this bulletin.

A student is expected to complete his registration during the officially designated period and to attend the first meeting of all classes in which he is enrolling. If this is impossible because of some emergency or unusual circumstance beyond his control, the student may be granted permission by his instructor to miss a few class meetings, it being understood that work missed will be made up subsequently. Under these conditions the Dean of the Graduate School may grant the student permission to register late. In general, a student who receives permission to register late will be required to reduce his program in proportion to the length of time he has been absent.

Regardless of when he may begin attending classes, a student who fails to complete the process of registration within the officially designated registration period will be liable for the late registration charge.

CONTINUITY OF REGISTRATION—A student who registers at University Park without interruption for each of the three terms in the September to June interval, for all four terms each year, or for each summer term is considered to have maintained a normal continuity of registration.

Anyone who has interrupted such a normal sequence and now plans to register for work at the University Park Campus is required to apply to the Dean of the Graduate School at least one month before the time of registration for permission to resume study.

The policy may be summarized for any specific term as follows:

Summer Term—Application required unless the student was registered at University Park for the preceding spring term or the preceding summer term.

Fall Term—Application required unless the student was registered at University Park for the preceding summer term or the preceding spring term.

Winter Term—Application required unless the student was registered at University Park for the preceding fall term.

Spring Term—Application required unless the student was registered at University Park for the preceding winter term.

PROCEDURE—For each registration the student, in consultation with his adviser, prepares a schedule of courses and research designed to fit his individual needs. The credit load will be reviewed by the Dean of the Graduate School at the time of registration. The registration process is completed in the manner specified for all students at the University.

Under certain conditions credit may be earned by work done away from the campus. A student contemplating such work should inquire of the Dean of the Graduate School about the procedures and conditions. The student must assume responsibility for the registration process, but the operation can be handled by mail. Registration must be completed before the close of central registration at University Park.

A student must register for courses audited as well as for those taken for credit.

REGISTRATION NEAR THE COMPLETION OF A PROGRAM—A candidate for the Ph.D. degree who is following the new regulations, which went into effect in the fall term 1967, is required to register continuously (at least three terms per calendar year) from the time he has both passed the comprehensive examination and met the three-term full-time academic requirement until his thesis is accepted by his doctoral committee, regardless of whether he is working on his thesis during this interval. These candidates are also required to be registered for the term in which they graduate.

Other doctoral candidates and master's students may be required to register for a normal credit load because of their appointment status. If not, and if they have earned more than 90 or 30 credits, respectively, and have met the requirements for their degrees except for the completion of the thesis, these students may register for as few as two credits per term. A student who has met the minimum requirements for his degree and is now completing his research and thesis writing off campus is not required to register, even if he comes to the campus several times each term to see his adviser.

A student, other than one following the new Ph.D. requirements, is not required to register for his final term in order to graduate or in order to make minor revisions to his thesis and/or to take a final examination for his degree.

VISITING AND AUDITING CLASSES—A graduate student who wishes to attend classes without receiving credit may secure permission either to visit or to audit courses during a term for which he has registered.

As a visitor, a student may attend classes with the approval of the instructor but may not claim the usual privileges of class membership such as participating in discussion, doing practicum work, or taking examinations. He does not register for the privilege of visiting, nor does any record appear on his transcript.

As an auditor, a student may participate in class discussion, do practicum work, take examinations, and generally share the privileges of a class member. The student registers in the same manner as if he were taking the course for credit and pays the same fees. He receives no credit and cannot subsequently secure credit for work done in the course; however, the Records Office shows on the grade report and the record the actual number of credits assigned to the course. Thus, when a student receives an audit grade, the number of credits which he audited is shown.

A student who, because of his status as a graduate assistant or fellow, is required to register for a certain minimum number of credits is not permitted to count those courses for which he is registering as an auditor for this purpose. The 1G and 2G language courses are an exception. Beyond the required minimum he may register for credit or audit but may not exceed the normal maximum without special permission.

In general, students are encouraged to visit classes rather than to register for a course as auditors. However, visiting is not permitted in German 1G and 2G.

In the 1G and 2G courses offered by the language departments, no distinction is made between registering for credit and for audit in considering loads. If the student does not have a reasonable background in the language, he will be required to count the course as part of his permissible load regardless of whether he registers for credit or for audit. If he has had the language before and is taking the course as a refresher, he may, with the permission of the Graduate Dean, take the course as an overload regardless of whether he registers for credit or audit.

RESEARCH AND THESIS WORK—In registering for thesis work a student uses the appropriate number (600, 601, 610, or 611) preceded by the abbreviation designating his major field. Thus, ENGL 600 denotes thesis research in English being done on the University Park Campus and ENGL 610 thesis research in English being done off campus.

The numbers 601 and 611 are available only to Ph.D. candidates who are following the new regulations, have passed the comprehensive examination, and have met the three-term, full-time academic requirement. Such a candidate in engineering mechanics will register for E MCH 601 if he will be using University facilities and/or

faculty services or for E MCH 611 if he will be off campus and requiring little or no faculty service.

It should be assumed that 600 and 610 are available in all graduate major programs and that 601 and 611 are available in all programs approved for the Ph.D., although these numbers may not always appear in the *Schedule of Classes* for each term.

COMMON COURSES—The following courses for which students may register have been set up for common use by major programs, with Senate approval, to encourage innovation and provide flexibility in designing graduate programs:

590. Colloquium (1-3) Continuing seminars which consist of a series of individual lectures by faculty, students, or outside speakers.

596. Individual Studies (1-6) Creative projects including nonthesis research, supervised on an individual basis and which fall outside the scope of formal courses.

597. Special Topics (1-6) Formal courses given on a topical or special interest subject which may be offered infrequently; several different topics may be taught in one year or term. A specific title may be used in each instance and will be entered on the student's transcript. Multiple offerings may be accommodated by the use of suffixes (a), (b), etc.

LOADS, ACADEMIC AND EMPLOYMENT—To provide flexibility in arranging loads for graduate assistants and full-time University staff members, a procedure has been set up whereby the normal credit limits may be changed by permission of the person to whom the student or staff member is responsible for his service assignment or University employment. Responsibility for the consequences of a graduate student's changing his course load rests with the student and his adviser. The course load is a factor in determining whether a graduate student is classified as a full-time or part-time student; has established residency requirements; and is eligible to hold a fellowship, scholarship, assistantship, or departmental or program appointment. In addition, it is important in determining military draft status.

The University takes the position that the facilities of the Graduate School should be made available only to students who can profit from their graduate school experience to the maximum extent. More than doing what is required in courses or in research, the graduate experience is one of living in a scholarly atmosphere and seriously engaging in scholarly pursuits. It means profiting from hearing visiting scholars and artists and from engaging in discussions, both formal and informal, with faculty members and fellow students. It is an involvement and participation in student affairs, University and Graduate School governance, committee assignments, and personal contribution of effort to the welfare and betterment of the University graduate community. It should mean leisure time for reflection and for exploring fields related to, although not directly a part of, one's specialty. Students who propose schedules of few credits not requiring serious effort, or those who wish to carry overloads of such proportion as to handicap them seriously in achieving maximum quality find it difficult and often impossible to experience the satisfaction of a well-rounded scholarly attainment.

Thus a graduate student should strive for a balance between his academic load, employment, or appointment which will classify him as a full-time graduate student with all the privileges and responsibilities intrinsic to this classification, and he should be so certified by his department head or program chairman.

FULL-TIME ACADEMIC LOADS—In establishing credit loads, a student is classified as full-time in any term for which he is registered for 8 to 10 credits, *or* holds a quarter-time assistantship and schedules 7 to 9 credits, *or* has a half-time graduate assistantship and schedules 5 to 7 credits. A Ph.D. candidate following the new regulations and registered for noncredit 601 or 611 will be classified as full-time if

he is not employed in other work and if he is so certified by his department head or program chairman.

PART-TIME ACADEMIC LOADS—A part-time student or three-quarter-time graduate assistant is one who schedules 4 to 5 credits. A part-time student may also schedule 1 to 4 credits.

STAFF EMPLOYEE CREDIT LOADS—A full-time staff employee of the University may schedule 4 credits (up to 16 credits per academic year) per term, either for credit or audit.

No member of the faculty in one of the professorial ranks in the University may receive from the University the master's degree or the doctoral degree.

For University staff employees desiring to take graduate degree work, admission to the Graduate School is a first essential.

EMPLOYMENT—Many students depend upon part-time employment to help meet their expenses. A student who is thus employed, whether on campus or off campus, must recognize the time demands of his work schedule in planning his academic program. A student holding a fellowship or scholarship may not accept employment of any kind for service beyond that specified by his appointment. Graduate assistants may accept concurrent employment outside the University only after obtaining permission from the head of the department providing the assistantship or from the person in charge of his graduate program. A graduate assistant may not hold a concurrent appointment with the University other than a Fellowship Supplement.

COURSE NUMBERING SYSTEM—Courses in the series 1-399 are not listed in this bulletin because they are strictly undergraduate and yield no graduate credit. A graduate student may register for or audit these courses in order to make up deficiencies or fill in gaps in his earlier education but not to meet requirements for an advanced degree.

Courses in the series 400-499 are for upperclassmen with at least junior standing and for graduate students. Only a limited number of credits earned in these courses may be counted toward the requirements for an advanced degree. Detailed regulations concerning the restrictions are given on pages 57-63 under the specific requirements for the various master's degrees.

Courses in the series 500-599 are restricted to students registered in the Graduate School, seniors with an average of at least 3.50, and other students who have been granted permission to enroll by the Dean of the Graduate School.

The numbers 600 (on campus) and 610 (off campus) are available for credit in thesis research in all graduate major programs. The numbers 601 and 611 do not denote courses but are used for noncredit registration by a Ph.D. candidate who is following the new regulations which went into effect in fall term 1967. Registration under these numbers will maintain his status as a student during the interval which begins at the time he has both passed the comprehensive examination and met the three-term, full-time academic requirement and ends at the time his doctoral committee accepts the thesis. The student will register for 601 if he will be using University facilities and/or faculty services; he will register for 611 if he will be off campus and requiring little or no faculty service. Candidates for the Ph.D. degree do not receive grades for noncredit registrations (601 and 611).

SCHEDULE OF COURSES—A complete list of the courses which will be offered in any specific term is given in the *Schedule of Classes*, which is available at nominal cost from the Scheduling Office approximately four months before the beginning of the term. It gives the number of credits being offered in each course, the hours at which the class will meet, the location of the class, and in some cases the instructor's name.

GRADING SYSTEM

A grade is given solely on the basis of the instructor's judgment as to the student's scholarly attainment.

The following revised grading system is now in effect: Any one of five quality grades (A, B, C, D, F) may be given a graduate student for course work or for thesis research. The grade-point equivalents are 4, 3, 2, 1, 0, respectively.

At the 400, 500, and 600 levels grades of A, B, and C denote graduate credit, whereas D and F are failing grades for graduate students, D being the normal failing grade. A grade of F indicates doubt in the judgment of the instructor of the student's potential for further graduate study.

A minimum grade-point average of 3.00 for work done at the University is required for graduation in the case of all candidates whose first registration for graduate study at the University occurred in the spring term 1964 or later.

In addition to the quality grades listed above, two symbols, "Def." (deferred) and "R," may appear on a student's transcript. If work is incomplete at the end of a term for a reason beyond the student's control, or if very little work remains to be done, the instructor may report "Def." in place of a grade, which will appear temporarily on the student's record.

In the case of thesis work, either in progress or completed, and certain courses approved by the University Senate, the instructor may report the symbol "R" in place of a grade. This symbol indicates that the student has devoted an adequate amount of time to the work scheduled but gives no indication of its quality. An "R" remains on the student's transcript permanently. If, after having submitted a series of "R" symbols, the instructor reports a grade of A, B, C, D, or F for a specific term, this grade is considered to apply to the preceding series of registrations and to denote the quality of that entire series.

UNSATISFACTORY SCHOLARSHIP

A graduate student who fails to maintain satisfactory scholarship or to make acceptable progress in his degree program will be dropped from the University. Action may be initiated by the department or committee in charge of the graduate major or by the chairman of the student's doctoral committee.

GRADUATION

It is the responsibility of the student to inform the Graduate Recorder of his intention to graduate (by filing a diploma card) and to pay the thesis fee at the beginning of the term in which he expects to receive an advanced degree. If he does not graduate that term, he must reactivate the diploma card by indicating to the Graduate Recorder the term in which he intends to graduate. Deadlines are given in the calendar found at the beginning of this bulletin.

See the *Manual for Graduate Students* for a detailed statement of procedure concerning graduation. Attendance at commencement exercises is expected, but permission to receive the degree in absentia may be granted by the Dean of the Graduate School.

All degrees conferred are tentative until final grade reports have been received, even though the student's name may have appeared in the commencement program.

TUITION AND CHARGES

The University reserves the right to revise the schedule of tuition and charges without further notice.

TOTAL TUITION FOR EACH TERM

University Park Campus and Medical Center (Nonmedical Students)—8 or more credits, total charge of $285 for Pennsylvanians and $662 for non-Pennsylvanians; 7 or fewer credits, $35 per credit for Pennsylvanians and $85 for non-Pennsylvanians. (Medical Students)—8 or more credits, total charge of $400 for Pennsylvanians and $800 for non-Pennsylvanians; 7 or fewer credits, $50 per credit for Pennsylvanians and $100 for non-Pennsylvanians. These rates apply also to off-campus research and other approved individual study.

Graduate Centers and Capitol Campus—8 or more credits, total charge of $280 for Pennsylvanians and $662 for non-Pennsylvanians; 7 or fewer credits, $31 per credit for Pennsylvanians and $85 for non-Pennsylvanians.

Continuing Education Centers—University Park, $35 per credit for Pennsylvanians and $85 per credit for non-Pennsylvanians; Graduate Centers and Capitol Campus, $31 per credit for Pennsylvanians and $85 per credit for non-Pennsylvanians.

Vocational Education Program—8 or more credits, total charge of $285 for Pennsylvanians and $662 for non-Pennsylvanians; 7 or fewer credits, $35 per total program for all students (vocational education courses are indicated by "v" following the course number).

Tuition is the same for courses whether audited or taken for credit.

Any student who does not fulfill payment obligations promptly may be charged a late payment fee of $25. A student whose account is delinquent for more than ten days is subject to suspension from the University.

Whenever it appears that an applicant for admission is not domiciled in Pennsylvania, it is assumed that he is a non-Pennsylvanian. If the student who is thus admitted believes that his circumstances do not justify his classification as a non-Pennsylvanian, he may petition the Graduate Dean's office for reclassification. (See Student Resident Status, page 41).

TUITION REFUND POLICY—Charges for tuition are refundable upon withdrawal from the University only in the event the student obtains an Official Withdrawal Form at the office of the Dean of the Graduate School and presents it, together with his current Certificate of Registration, at the office of the Fee Assessor no later than one calendar month after the effective date of withdrawal from classes. Students who meet these conditions are entitled to receive refunds of charges for tuition for the term in accordance with the following schedule:

> Refund of 80 per cent upon withdrawal before the end of the first week of the term (seventh consecutive calendar day from the first day of classes) and a decrease of 20 per cent for each week thereafter up to and including the fourth consecutive calendar week. No amount will be refunded for withdrawal after the fourth consecutive calendar week of the term.

The University will not release any refund of tuition until at least three weeks have elapsed from the date the payment was received. All refunds will be made by check and mailed to the student's home address.

SPECIFIC CHARGES—In addition to the foregoing tuition and charges, the following charges apply under special conditions and are to be paid independently:

Application fee	$ 15.00
Change of schedule, each change	2.00
Duplicate meal ticket	1.00
Duplicate student identification and activity card	each 4.00
French reading examination	6.00
Music, individual lessons	30.00 to 100.00

Privilege of late payment	25.00
Privilege of late registration	10.00
Dissertation fee for Ph.D. candidates (601)	100.00
Dissertation fee for Ph.D. candidates (611)	100.00
Student parking fee, each term	10.00
Teacher placement service registration fee	5.00
Teacher placement service reactivation fee	5.00
Thesis microfilming and binding fee for master's candidate	10.50
Thesis microfilming and binding fee for doctoral candidate	45.50
Transcript of records (with seal), each copy	1.00

MOTOR VEHICLE CHARGES—Each graduate student who possesses, maintains, or operates a motor vehicle (including a motorcycle, motor bike, motor scooter, or any other motor-driven vehicle) in Centre County is required to register such vehicle with the Traffic Violations Officer during the registration period of each term. There is no charge for registration for students who do not desire campus driving or parking privileges. Failure to register a vehicle renders a student liable for a fine of $15 for each offense.

A permit allowing limited driving and parking on the campus throughout the week costs $10 per term. A more restricted permit allowing driving and parking on the campus for evenings and weekends costs only $3.50 per term.

A graduate assistant pays no fee for the privilege of driving and parking on the campus but is required to comply with student regulations concerning motor vehicles. If a student lives for more than thirty consecutive days in the year in Pennsylvania, he shall be required to obtain Pennsylvania registration for his vehicle. A student's spouse may be required to register his or her car in Pennsylvania. A student registered to vote locally is a local resident.

LIVING ACCOMMODATIONS

Eastview Terrace and Graduate Circle, both located on the eastern side of the campus, provide one- and two-bedroom apartments for married graduate students.

The Eastview Terrace apartments are fire resistant, one-story, steel framework buildings. Forty-six one-bedroom units rent for $80 per month; thirty-two two-bedroom units rent for $90. The rent includes utilities except electricity. Water is heated electrically. The units are unfurnished except for electric stove and refrigerator. For each two units there is a utility room with two stationary laundry tubs and storage space.

Graduate Circle has 144 one-bedroom and 72 two-bedroom apartments in sixteen two-story buildings of brick and frame construction. The units rent for $90 and $100 per month, including all utilities. Each kitchen has a double stainless steel sink with disposal unit, a gas stove, kitchen cabinets, and an electric refrigerator; each bedroom has a built-in chest of drawers. Otherwise the units are unfurnished. There are no facilities for private washing machines in the apartment; however, coin-operated laundries at nominal fees are provided in five of the buildings throughout the area. A storage locker is also provided for each apartment at the laundry location.

Families with children of school age, or with children who will become of school age during the term of the lease, cannot be considered for occupancy in Eastview Terrace and Graduate Circle. The one-bedroom apartments are designed for a husband and wife and the two-bedroom units for a family with not more than two children. An agreement form for graduate housing may be obtained by submitting the "Request for Graduate Housing" card. This request card is to be mailed to the Assignment Office for Campus Residences, 101 Shields Building, University Park, Pa. 16802. Telephone: Area Code 814, 865-7501.

Atherton Hall, located near the Hetzel Union Building, and McKee Hall, located near the Graduate Center, are reserved exclusively for single graduate men and women, providing residence hall room accommodations without food service. Double, single, single occupancy of double rooms, or single room with bath are available at $160, $195, $210, and $210 per term, respectively. Fall Term Housing and Food Service Agreements must be submitted, with $45 advance payment, to the Bursar's Office, 103 Shields Building, University Park, Pa. 16802. THE ADVANCE PAYMENT WILL BE REFUNDED IF THE ASSIGNMENT OFFICE FOR CAMPUS RESIDENCES, 101 SHIELDS BUILDING, IS NOTIFIED OF CANCELLATION IN WRITING NO LATER THAN JUNE 15 OF EACH YEAR. STUDENTS NOT CANCELLING AS OF THIS DATE WILL BE OBLIGATED FOR THE ON-COMING FALL, WINTER, AND SPRING TERMS IF THEY ARE ENROLLED AT THE UNIVERSITY PARK CAMPUS. AGREEMENTS FOR WINTER, SPRING, AND SUMMER TERMS DO NOT REQUIRE AN ADVANCE PAYMENT AND SHOULD BE MAILED DIRECTLY TO THE ASSIGNMENT OFFICE FOR CAMPUS RESIDENCES, 101 SHIELDS BUILDING, UNIVERSITY PARK, PA. 16802. The Hetzel Union Building cafeteria and snack bar are available for meals.

Separate dining hall meal tickets for one of eight campus dining halls may be purchased for $235 per term. Twenty-one meals per week are served, beginning with registration and ending with final examinations.

Other living accommodations available in the community may be located through the Chamber of Commerce, 129 West Beaver Avenue, State College, Pa. 16801; Telephone: Area Code 814, 237-7644. The cost of apartments or rooms in private homes or lodging houses varies considerably, depending upon the type of accommodations desired. Arrangements can best be made by a personal visit to the area.

Graduate students should arrange for their accommodations well in advance of the beginning of classes because it may be very difficult to find convenient housing at the last minute. STUDENTS MUST BE ADMITTED TO THE GRADUATE SCHOOL BEFORE THEIR REQUESTS FOR ON-CAMPUS LIVING ACCOMMODATIONS CAN BE PROCESSED.

DOCTORAL DEGREES

The Doctor of Philosophy, an academic degree, and the Doctor of Education, a professional degree, are conferred by the University. Recognized as different in purpose, the two programs consequently have different requirements in certain respects.

ADMISSION—A sudent who has been admitted to the Graduate School and has been accepted by the department or committee in charge of a major program in which the doctorate is offered may begin working toward a doctor's degree. However, he has no official status as a doctoral student and no assurance that he will be accepted as a doctoral candidate until he has passed a candidacy examination. This examination is administered by the major department or graduate program and is given early in the student's program.

GENERAL REQUIREMENTS—No specified number of courses completed or credits earned will assure attainment of the doctorate. The general requirements are based upon a period of residence, the writing of a satisfactory thesis, and the passing of a comprehensive and a final oral examination. A doctoral program consists of such a combination of courses, seminars, and individual study and research as meets the minimum requirements of the Graduate School and is approved by the doctoral committee for each individual student.

A master's degree is not a prerequisite for the doctorate in some major programs. However, the first year of graduate study leading to the Ph.D. may be substantially

the same as that provided for the M.A. or M.S. degree. Similarly the first year of the D.Ed. program may be essentially the same as that provided for the M.Ed.

GRADE-POINT AVERAGE—A minimum grade-point average of 3.00 for work done at the University is required for admission to the comprehensive examination and for graduation in the case of all candidates whose first registration for graduate study at the University occurred in the spring term 1964 or later.

TIME LIMITATION—A student is required to complete his program within seven years from the date of his acceptance as a candidate.

OFF-CAMPUS AND TRANSFER CREDITS—Subject to the approval of his adviser and the head of his major department or program chairman, a student may register for research to be done away from the University Park Campus.

A maximum of 30 credits beyond the baccalaureate at an approved school not granting the doctorate in the student's major program may be accepted by the Graduate School in partial fulfillment of the requirements for a doctoral degree at The Pennsylvania State University. A maximum of two full academic years of work (60 credits) beyond the baccalaureate at a graduate school which grants the doctorate in the candidate's major program may be accepted here to apply toward doctoral degree requirements. Academic work to be so transferred must meet the following criteria: (1) It must have been completed within five years prior to the date of admission to the Graduate School of The Pennsylvania State University, (2) it must appear on a graduate transcript, (3) it must be of at least "B" quality, and (4) it must be deemed applicable to the student's program by his current academic adviser.

The following caveat should be noted. Pass-fail grades are not transferable to an advanced degree program unless the "pass" can be substantiated by the former institution as having at least "B" quality.

A completed master's degree may be transferred to a doctoral program with no intervening time limitation.

Forms for transfer of credit may be obtained from the Office of Graduate Admissions, 308 Kern Graduate Building.

ADVISERS AND DOCTORAL COMMITTEES—After a student has been admitted to a degree program, he should confer with the head of his major department or program concerning procedures and the appointment of an adviser. Arrangement and approval of the details of the student's term-by-term schedule is the function of the adviser. This person may be a member of the doctoral committee or someone else designated by the head of the major program for this specific duty.

General guidance of a doctoral candidate is the responsibility of a doctoral committee consisting of four or more members of the Graduate Faculty. One member shall be from outside the candidate's major program. This committee is appointed by the Dean of the Graduate School, upon recommendation of the head of the major program, after the student is admitted to candidacy. At his discretion, the Dean may add other members to the committee. The supervisor of the candidate's thesis will usually, but not necessarily, be designated as chairman. The chairman must hold senior membership in the Graduate Faculty. An associate member may not exclusively supervise the research for a doctoral candidate, but he may serve with a senior member as cochairman of a doctoral committee and/or as coadviser with a senior member, and thus may sign the title page of a thesis.

The doctoral committee is responsible for establishing the broad outline of the student's program and should review the program as soon as possible after his admission to candidacy. It will prepare, give, and evaluate the candidate's examinations, and supervise and approve his thesis. A favorable vote of at least two-thirds of the members of the committee is required for passing a comprehensive or a final oral examination. If a candidate fails an examination, it is the responsibility of the doctoral committee to determine whether he may take another examination.

The committee will also notify the Dean when the candidate is ready to have his comprehensive and his final oral examination scheduled and will report the results of these examinations to the Dean.

COMMUNICATION AND FOREIGN LANGUAGE COMPETENCE—A candidate for the degree of Doctor of Philosophy is required to demonstrate high-level competence in the use of the English language, including reading, writing, listening, and speaking. Proficiency is expected at the time of admission to the Graduate School or must be achieved before admission to candidacy.

In addition to demonstrating competence in English, each candidate for the Ph.D. must meet the communication and foreign language requirement which has been established by his major program with the approval of a Graduate School advisory committee.

If a candidate is to be examined for a reading knowledge of a foreign language other than French or Spanish, he must report his intention to take the examination to the secretary of the language department by the end of the first week of classes for the term during which he wishes to take it. This date is one week prior to the examination date. The examination will be administered on dates announced in the graduate calendar at the beginning of this bulletin.

If a student is to be examined in French or Spanish, he must make application for the Graduate School Foreign Language Tests through the Educational Testing Service at Princeton, N. J., by returning a completed registration form to Princeton prior to the registration dates listed in the Graduate Calendar. All dates refer to the date of receipt at ETS. The Pennsylvania State University has been named as a testing center for the administration of the written tests. Registration materials are obtainable from the Graduate School reception office, 205 Kern Graduate Building, or the student may write directly to Educational Testing Service.

Each candidate must submit the proper fee of $10 per test with his registration form. A penalty fee of $3.50 is assessed for registrations received at ETS one week after the publicized registration date.

Candidates for the Doctor of Education degree may be required to demonstrate competency in foreign languages.

CANDIDACY EXAMINATION—This examination is administered by the Graduate Faculty in the major graduate program and should be taken early in the student's program. The nature of the examination varies with the program and may be the master's examination if so allowed. The decision to admit a student to candidacy or to reject him must be made by Graduate Faculty or a designated committee of Graduate Faculty. For the Ph.D. student following the new requirements, the examination may be given after he has earned at least 12 credits in graduate courses beyond the baccalaureate. He must take the examination not later than three terms in which he has registered after earning 24 credits.

For all other Ph.D. and D.Ed. students, the examination should be given when the student has earned a total of approximately 30 credits, including his master's program and work done elsewhere. A student transferring from another graduate school with 30 or more transfer credits must be given the candidacy examination before he has earned more than 10 credits here.

COMPREHENSIVE EXAMINATION—When a candidate for the Ph.D. or D.Ed. degree has substantially completed his course work, he is required to take a comprehensive examination covering his major program and minor field of study.

A candidate for the Ph.D. must have satisfied the communication and foreign language requirement before taking the examination.

All candidates whose first registration for graduate study at the University occurred in the spring term 1964 or later are required to have a minimum grade-point average of 3.00 for work done at the University at the time the comprehensive examination is given.

The examination is officially scheduled and announced by the Dean of the Graduate School upon recommendation of the doctoral committee. It is given and evaluated by the doctoral committee and may be *either written or oral, or both.* A favorable vote of at least two-thirds of the members of the committee is required for passing. In case of failure it is the responsibility of the doctoral committee to determine whether the candidate may take another examination. The results are reported to the Dean of the Graduate School, and will be entered on the candidate's official record.

When a period of more than five years has elapsed between the passing of the comprehensive examination and the completion of his program, the student is required to pass a second comprehensive examination before the final oral examination will be scheduled.

FINAL ORAL EXAMINATION—The doctoral candidate who has satisfied all other requirements for the degree will be scheduled by the Dean of the Graduate School, on recommendation of the doctoral committee, to take a final examination. Normally the final oral examination may not be scheduled until at least three months have elapsed after the comprehensive examination was passed, although the Graduate Dean may grant a waiver in the case of an outstanding student. The deadline for holding the examination is seven weeks before commencement.

The final examination is oral, open to the public, and related in large part to the thesis; but it may cover the candidate's whole program of study without regard to courses that have been taken either here or elsewhere.

A favorable vote of at least two-thirds of the members of the committee is required for passing. The results of the examination are reported to the Dean of the Graduate School and will be entered upon the candidate's official record. If a candidate fails, it is the responsibility of the doctoral committee to determine whether he may take another examination.

Ph.D.—ADDITIONAL SPECIFIC REQUIREMENTS

The degree of Doctor of Philosophy is conferred in recognition of high attainment and productive scholarship in some special field of learning as evidenced by (1) the satisfactory completion of a prescribed period of study and investigation, (2) the preparation of a thesis involving independent research, and (3) the successful passing of examinations covering both the special subject and the general field of learning of which this subject forms a part.

In the fall term 1967 a revised set of requirements for the Ph.D. went into effect. A student who, by the end of the summer term 1967, had earned 45 or fewer graduate credits which were applicable toward his degree follows the new requirements.

RESIDENCE REQUIREMENTS—There is no required minimum of credits or terms of study, but over some twelve-month period during the interval between admission to candidacy and completion of the Ph.D. program the candidate must spend at least three terms (which may include the term in which the candidacy examination is taken) as a registered student, during which time he is engaged in full-time academic work on the University Park Campus or at The Milton S. Hershey Medical Center *and* is certified by his department as devoting half time or more to graduate studies and/or thesis research to meet his degree requirements.

After a student has passed the comprehensive examination and met the three-term residence requirement, no further registration for credit will be required by the Graduate School. He shall, however, maintain his status as a student by registering continuously (at least three terms per calendar year) until the thesis is accepted by his doctoral committee. This registration may be for (1) courses for credit, for which the student will pay the regular per credit fee of $32 (in-state residency) and $85

(out-of-state residency), (2) noncredit, on-campus thesis preparation (601) for which the student pays a dissertation fee of $100, or (3) noncredit, off-campus thesis preparation (611) for which the student pays a dissertation fee of $100. Grades are not given for noncredit 601 or 611.

OLD RESIDENCE REQUIREMENTS—A student who had earned more than 45 credits by the end of the summer term 1967 will be required to span a minimum of nine terms in full-time graduate study and research (10 credits per term), or their equivalent in credits (90 credits), for the Ph.D. At least 30 credits must be earned in residence at the University Park Campus.

For a period of three terms, two of which must be consecutive, the Ph.D. candidate must limit his work load to half-time at most, the balance of his time being devoted to graduate study.

A graduate assistant or research assistant who is a candidate for the doctorate, has passed the comprehensive examination, is registered for the maximum allowable credit load, and is certified by his department as devoting all his time to studies and thesis research to meet his degree requirements may be regarded by the Dean of the Graduate School as a full-time student for a period not exceeding one calendar year. Such a student will be considered to earn the equivalent of 10 credits per term, and three such terms will meet the minimum residence requirement for the Ph.D.

MINOR FIELD—A Ph.D. candidate is not required by the Graduate Faculty to have a minor field of study. However, a department or a committee in charge of a major field may require a candidate to offer work in a minor field, or a student may elect such a program with the permission of his doctoral committee.

A minor consists of no fewer than 15 credits, including those applied toward the master's degree, of integrated or articulated work in one field related to, but different from, that of the major. A minor program must meet the approval of the departments or committees responsible for both the major program and the minor field.

THESIS—The ability to do independent research and competence in scholarly exposition must be demonstrated by the preparation of a thesis on some topic related to the major subject. It should represent a significant contribution to knowledge, be presented in a scholarly manner, reveal an ability on the part of the candidate to do independent research of high quality, and indicate considerable experience in using a variety of research techniques. The contents and conclusions of the thesis must be defended at the time of the final oral examination.

The completed thesis, together with a separate copy of an abstract, must be filed in the Office of Theses and Publications not later than five weeks prior to the commencement at which the candidate expects to receive the degree.

A Thesis Information Bulletin, which gives details concerning format, paper, illustrations, and other items, may be obtained at the Graduate School Office of Theses and Publications, 320 Graduate Building.

D.Ed.—ADDITIONAL SPECIFIC REQUIREMENTS

Programs leading to the degree of Doctor of Education are not limited to specific fields of education but, with the consent of the department or committee in charge, may also be offered in any other field appropriate to the preparation of teachers which has been approved for the doctorate.

The degree is conferred in recognition of advanced preparation of a high order for work in the profession of education as evidenced by (1) satisfactory completion of a prescribed period of study; (2) ability to apply scientific principles in classroom instruction, supervision of instruction, administration, or as a consulting specialist in cer-

tain educational areas; (3) preparation of a thesis demonstrating ability to undertake an educational problem with originality and independent thought; and (4) successfully passing examinations, i.e., showing a satisfactory grasp of the field of specialization and its relation to allied educational areas.

RESIDENCE REQUIREMENTS—A minimum of nine terms of full-time graduate study and research (10 credits per term), or their equivalent in credits (90 credits), of which at least 30 credits must be earned in residence, is required for the D.Ed. degree. The D.Ed. candidate may meet the requirements by attending summer terms unless his major department requires a period of registration in other terms or in consecutive terms at University Park. A candidate may register for a maximum of 30 credits of research in absentia, but none of these may count toward the minimum of 30 credits which he is required to earn on the University Park Campus. It is expected that students will register for a minimum of 15 credits of thesis research. The maximum credit load permitted a student who is employed full-time is 4 credits per term.

MAJOR PROGRAM AND MINOR FIELD—The program of study includes a major and either a minor or a group of general studies. A majority of the courses offered in fulfillment of the requirements must be in the major program of study.

A candidate choosing a major outside the fields of education (such as speech, geography, or history) shall have a minor consisting of no fewer than 15 credits, including those applied toward the master's degree, in educational foundations, which includes courses in comparative education, educational measurements and statistics, educational psychology, history of education, and philosophy of education.

A candidate choosing a major in one of the major programs in education must also choose either a minor or a group of general studies with the approval of the major program chairman. In this case a minor consists of no fewer than 15 credits, including those applied toward the master's degree, in one field outside those of education. An acceptable general studies group consists of no fewer than 15 credits, including those applied toward the master's degree, in fields outside those of education considered by the major program committee to have significance and value for the candidate.

COMPREHENSIVE EXAMINATION—In addition to demonstrating a high level of competence in the subject matter of his major program and minor field, each candidate must show in his comprehensive examination that he is familiar with current theories of education; that he understands and can apply the techniques and the findings of educational research so far as they bear upon the teaching of his subject; that he is prepared to read understandingly and contribute to the technical and professional literature in his field; and that he can criticize his own procedures in the light of historical trends and practices in this and other countries. Command of the tools for a thorough study of the problems of education is necessary and must include familiarity with statistical methods. For certain students the requirements may include a reading knowledge of one or more foreign languages.

All candidates whose first registration for graduate study at the University occurred in the spring term 1964 or later are required to have a minimum grade-point average of 3.00, for work done at the University, at the time the comprehensive examination is given.

THESIS—Evidence of a high degree of scholarship, competence in scholarly exposition, and ability to select, organize, and apply knowledge must be presented by the candidate in the form of a written thesis. The candidate must demonstrate a capacity for independent thought as well as ability and originality in the application of educational principles or in the development of new generalizations under scientific controls. A thesis may be based upon a product or project of a professional nature, provided scholarly research is involved. For example, it may be based upon the solution of a professional problem concerned with the development of a curriculum, or a product

of creative effort related to education. However, in order to be acceptable as a thesis, the professional project must be accompanied by a written discourse demonstrating the nature of the research and including such theories, experiments, and other rational processes as were used in effecting the final result. The topic and outline of the proposed thesis must have the approval of the doctoral committee.

The completed thesis, together with a separate copy of an abstract, must be filed in the Office of Theses and Publications not later than five weeks prior to the commencement at which the candidate expects to receive the degree.

A Thesis Information Bulletin, which gives details concerning format, paper, illustrations, and other items, may be obtained at the Graduate School Office of Theses and Publications, 320 Graduate Building.

MASTER'S DEGREES

The Graduate School recognizes a difference in purpose, which is reflected in the requirements, for two types of advanced degrees, academic and professional. Of the twelve master's degrees conferred, the Master of Arts and the Master of Science are academic in nature. The professional degrees conferred are Master of Administration, Master of Agriculture, Master of Business Administration, Master of Education, Master of Engineering, Master of Environmental Pollution Control, Master of Fine Arts, Master of Forestry, Master of Public Administration, and Master of Regional Planning.

A degree is not conferred for a mere collection of credits. A well-balanced, unified, and complete program of study will be required, which may frequently exceed the minimum requirements specified below.

A student may meet the degree requirements by either full-time or part-time enrollment and by attendance in any combination of terms. The student who interrupts the continuity of his registration faces the possibility of not being granted permission to return.

GRADE-POINT AVERAGE—A minimum grade-point average of 3.00 for work done at the University is required for graduation in the case of all candidates whose first registration for graduate study at the University occurred in the spring term 1964 or later.

TIME LIMITATION—All requirements for a master's degree, whether satisfied on the University Park Campus or elsewhere, must be met within six years or a period spanning seven consecutive summers.

ADMISSION—In addition to the general University requirements for admission set forth at the beginning of this bulletin, adequate undergraduate preparation is required in the program in which the applicant expects to pursue advanced work. The specific courses and the total number of undergraduate credits required in various areas will be determined by the choice of program and can be ascertained from the descriptive statement appearing under the major program heading in the latter portion of this bulletin. An applicant who meets the necessary grade-point average but is deficient in course preparation may, under certain circumstances, be admitted to the Graduate School and allowed to make up the undergraduate deficiencies. Under these circumstances the program will require more than the necessary period of residence. An applicant for admission to the M.Ed. program in most major programs is required to have had at least 18 credits in education and related psychology, and in certain major programs may be required to have had practice teaching.

After a student has been admitted to a degree program, he should confer with the head of his major department or program concerning the appointment of an adviser. The general guidance of a master's candidate is the responsibility of an adviser, or of a committee appointed in a manner to be determined by the major department or program in which the student is specializing. The adviser or the committee assists

the student in planning a program of study. Although the adviser is frequently the supervisor of the thesis, this is not necessarily the case.

Requirements concerning courses, language proficiency, minors, comprehensive examinations, and other matters are sometimes made by departments or programs in addition to (but not in conflict with) the regulations of the Graduate School. For details the student should consult the head of the major department or program.

TRANSFER CREDIT—Subject to the limitations given below on the use of credits earned away from the University Park Campus, a maximum of 10 credits of high quality graduate work done at another institution may be applied toward a master's degree here.

The student should distinguish carefully between the transferability of credit and its applicability in a particular degree program as approved by his academic adviser. Such academic work transferred must have been completed within five years prior to the date of admission to the Graduate School of The Pennsylvania State University, must be of at least "B" quality, and must appear on a graduate transcript.

Pass-fail grades are not transferable to an advanced degree program unless the "pass" can be substantiated by the former institution as having at least "B" quality.

Forms for transfer of credit may be obtained from the Office of Graduate Admissions, 308 Kern Graduate Building.

EXAMINATIONS—In addition to the examinations specifically required by the regulations of the Graduate School, a candidate may be required to pass in a satisfactory manner such other written or oral examinations as his department may designate. A candidate should consult his major department for such special requirements.

Examinations to establish credit for work done *in absentia* or without formal class work may be used to remove undergraduate deficiencies, but *not* to earn credits toward an advanced degree. Arrangements are made by the student directly with his major department or program.

Graduate Record Examinations are designed to test information and abilities in basic fields of knowledge. Provisions are made on the campus for administering these examinations at scheduled times and upon request of students or department program chairmen. Further information may be obtained from the Office of Graduate Student Programs.

ENGLISH PROFICIENCY OF FOREIGN STUDENTS—Entering graduate students from countries other than the United States are required to demonstrate high-level competence in the use of the English language, including reading, writing, speaking, and listening. Upon arrival at the University, such students are requested to report to the International Center, 111 Kern Graduate Building, where an appointment for the English language proficiency interview will be made. Students with an obviously good command of English will be exempted from formal testing; others will be scheduled for a series of proficiency tests. The Graduate School at The Pennsylvania State University requires all foreign graduate students who are working toward a degree to pass an English language examination. Remedial work will be prescribed as indicated by the tests.

Before a foreign student can be accepted for enrollment at The Milton S. Hershey Medical Center a high-level competence in the use of the English language must be demonstrated by successful performance on the TOEFL (Test of English as a Foreign Language). Information on the time and place that this test is given in his geographical area can be obtained by writing to the Educational Testing Service, Box 592, Princeton, N. J. 08540.

M.A. and M.S.—ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Arts and the Master of Science degrees have similar requirements, the general major area determining which degree is conferred. Programs for both degrees are strongly oriented toward research.

A minimum of 30 graduate credits is required, of which at least 20 must be earned on the University Park Campus or at The Milton S. Hershey Medical Center. A minor is not required of all candidates for the M.A. or M.S. degree. A department or committee in charge of a major program may require a candidate to offer work in a minor field, or a student may elect such a program with the permission of his committee.

A minor consists of no fewer than 6 credits of integrated or articulated work in one field related to, but different from, that of the major. A minor program must meet the approval of the departments or committees responsible for both the major program and minor field.

The major department or the committee in charge of the major program is the judge as to the suitability of a field for the minor and of its relevance to the major. The minor field department has the responsibility of accepting or rejecting students, advising on courses to be taken by the candidate in the field, examining the candidate in the area of studies he has undertaken in the field, and certifying that the minor requirements have or have not been met.

At least 18 credits in the 500 and 600 series combined must be included in the program. A minimum of 12 credits in course work (400 and 500 series), as contrasted with research, must be completed in the major program. A thesis is required of many candidates for these degrees. Details are given in the introductory paragraphs under the major program headings in the latter part of this bulletin. If a student is required to write a thesis, at least 6 credits in thesis research (600 or 610) must be included in his program. If no thesis is required, at least 18 credits must be in 500 courses.

Those candidates who are not required to write a thesis must present a suitable essay or paper. Its nature and extent shall be determined by the major program. The department head or program chairman shall report to the Dean of the Graduate School the title, the name of the faculty member under whom the student did the work, and whether the work was considered adequate. The program head may require one or more copies of such an essay for its library or other files.

A thesis is prepared under the direction of the department or program in which the candidate's major work is taken. Under certain conditions a student may complete the thesis off campus. To do so he must make satisfactory arrangements in advance with his adviser and the head of his major department or program.

Requirements for the M.A. degree at the Capitol Campus differ somewhat from the above and are outlined under the major programs in American studies and humanities. These programs are available only at the Capitol Campus.

A *Thesis Information Bulletin,* which gives details concerning format, paper, illustrations, and other items, may be obtained at the Graduate School Office of Theses and Publications, 320 Kern Graduate Building.

M.Adm.—ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Administration degree program is intended to meet the professional needs of practicing and potential administrators in the fields of business, engineering, government, health, and social service. All students must satisfy preparatory requirements for their particular program and complete at least 30 credits of graduate courses, with the majority of the courses at the 500 level. Three options are offered:

(1) the business administration option is intended for students who desire to pursue an administrative career in business, industry, or institutions, (2) the engineering administration option prepares individuals for management positions in engineering, scientific, and technical organizations, and (3) the public administration option prepares individuals for administrative responsibility in local, state, or federal government, institutions, and social service agencies. Each student is required to complete a professional paper of the quality, if not the theoretical depth, of a thesis and it must be defended before a committee of Graduate Faculty members. The candidate will be expected to demonstrate his ability to integrate knowledge of a specialized area with a broad understanding of the general field of administration.

The program is offered only at the Capitol Campus.

M.Agr.—ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Agriculture is a professional degree. Thus, programs leading to this degree provide opportunities for students to increase their knowledge and competences in the various phases of agriculture. A student, according to his needs, may obtain (1) intensive training encompassing a wide spectrum of subject matter area or (2) intensive training in a specialized area. The emphasis of the program is to enable students to develop skill as professional practitioners in the communication of technical knowledge and its application to the solution of current and future technical, economic, and social problems of individuals and groups.

The head of the department or program chairman shall appoint a three-member committee to guide and monitor the candidate's professional development. Members of this committee must represent at least two departments. The chairman of the appointed committee shall serve as the candidate's adviser. Early in his program, the candidate will inform the committee of his background and aspirations. The committee will suggest to the student how best to achieve these goals and the standard of professional competence required for the Master of Agriculture degree.

A minimum of 30 graduate credits is required of which 20 credits must be earned in residence at the University Park Campus. A maximum of 10 credits may be earned in special problem type courses.

The candidate must present an acceptable paper on a selected professional problem or a report of internship training. Up to 3 graduate credits will be given for an acceptable paper. The candidate may be required to provide one or more copies of the paper for the University.

The candidate's committee shall report through the department head or program chairman to the Dean of the Graduate School the title of the paper and whether the paper and the candidate's academic performance were considered satisfactory.

M.B.A.—ADDITIONAL SPECIFIC REQUIREMENTS

The purpose of the Master of Business Administration degree program is to develop professional managerial knowledge and skills as these are applied to the decisions in business enterprises. Teaching focuses upon the techniques, the theory, and the skills important to modern administrators.

At least 36 graduate credits are required of which 18 or more are to be completed at the 500 level and 26 hours at University Park. Candidates who are admitted without an undergraduate business background may be required to undertake up to 30 hours of work preparatory to full status as a M.B.A. candidate. During the later

stages of course work, some specializations within a major area of student interest and a M.B.A. project paper are undertaken. Applications must include the results of the Admission Test for Graduate Study in Business sent directly from the Educational Testing Service.

M.Ed.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Education provide preparation for increased professional competence in the areas of education and teaching. They should be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Arts or Master of Science. In most major programs the requirements for admission include 18 credits in education and related psychology.

A minimum of 30 graduate credits is required for the degree, of which at least 20 must be earned on the University Park Campus; at least 24 must be in course work. This degree is offered also at the Capitol Campus and the King of Prussia Graduate Center.

MAJOR PROGRAMS IN THE FIELDS OF EDUCATION—A student may major in one of the approved programs in education, such as elementary education, art education, or home economics education, and proceed under the guidance of the appropriate major in education.

A program of this type requires at least 6 credits to be earned outside the programs in education.

MAJOR PROGRAMS OUTSIDE THE FIELDS OF EDUCATION—A student who is preparing to teach in a specific subject-matter field, such as geography, mathematics, or German, may choose such a program as his major and take the majority of his work in it under the guidance of the department offering that major. A student wishing to work in a broader area may choose a major such as biological science, earth sciences, physical science, or social studies and take at least 24 credits in the area under the guidance of the committee in charge of the major.

Each candidate is required to earn 6 credits in education as directed by the faculty of one of the approved graduate programs in education. The 6 credits may be taken in educational foundations, which includes courses in comparative education; history, sociology, and philosophy of education; and educational psychology.

THESIS OR PAPER—Six credits may be granted for an approved thesis. A candidate who does not elect to write a thesis is required to present an essay or paper. It must be of considerable proportion, indicating capacity to describe a serious intellectual experience adequately in writing, and giving unmistakable evidence of ability to formulate and state meaningfully the purpose of an investigation, study, critical analysis, or evaluation; to acquire and analyze information; to draw conclusions logically; and to relate findings to professional problems and practices. The nature and extent of such a piece of writing, whether it be required in connection with a course or independently of course work, and when it is to be undertaken shall be determined by the major program. The department head or program chairman shall report to the Dean of the Graduate School the title, the name of the faculty member under whom the student did the work, and whether the work was considered adequate. It is the right, but not the responsibility, of the department head or program chairman to require one or more copies of such an essay for its library or other files.

M.Eng.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Engineering provide training for advanced professional competence in the several fields of engineering. They should be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Science.

A minimum of 30 graduate credits is required, of which at least 12 must be earned in graduate courses (500 series).

A scholarly written report on a developmental study involving at least one area represented in the candidate's course work is required as an integral part of the program. The report must be comparable in its level of work and quality to a graduate thesis. The topic of the developmental study is subject to prior approval by the department in which the candidate's major work is taken, and preparation of the written report shall be under the direction of that department.

No work for this degree is required to be done specifically on the University Park Campus provided the major department or supervisory committee and the Dean of the Graduate School agree that a complete program of study can be pursued at the Capitol Campus or an established Graduate Center of The Pennsylvania State University.

M.E.P.C.—ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Environmental Pollution Control is an intercollege professional degree designed for students who are interested in pursuing a career in the field of environmental pollution control. Special requirements include 9 credits of core courses covering air and water pollution control and solid waste management and participation in the environmental pollution control seminar program. A minimum of 30 graduate credits are required of which at least 9 must be at the 500 level and 20 must be taken at the University Park Campus. A thesis will be optional. If a thesis is written, at least 6 credits of thesis research (600 or 610) must be taken.

M.F.A.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Fine Arts provide training for increased professional competence in the several specialized areas of the arts. They should be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Arts with a major in art, music, or theatre arts.

A minimum of 48 credits is required, of which at least 38 must be earned on the University Park Campus. The larger part of these credits should be above the 400 level, but the needs of the student shall be considered in arranging the best combination of courses and research for the preparation of the candidate in his particular field.

A professional project, either creative or interpretative, is required. This project shall include a monograph in support of the creative or interpretative aspect; such monograph shall represent a minimum of 6 credits on the 600 level.

M.F.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Forestry provide training for increased professional competence in the several specialized areas of forest resource management and forest products. They should be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Science with a major in forest resources.

A minimum of 30 graduate credits is required, of which at least 20 must be earned on the University Park Campus.

A candidate for the degree of Master of Forestry should choose one area for his major and one or two related areas for his minor. The proportion of credits to be taken in the major and minor fields of study will be determined in consultation with the student's advisory committee. It is expected that the larger part of the program shall be in graduate courses (500 series), but no specific number of credits in the 500 series is required.

Each candidate is required to submit an acceptable thesis based on at least 6 credits of thesis research.

M.P.A.—ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Public Administration is a professional degree for students who are planning careers in public administration in local, state, and national governmental jurisdictions, or in international, private, or voluntary agencies. This program should be distinguished from the research-oriented program which leads to the academic degree of Master of Arts with a major in political science in which the candidate may specialize in public administration.

For the M.P.A. degree a minimum of 30 graduate credits is required, with the greater portion of the courses being at the 500 level. An M.P.A. essay or paper will also be required but will carry no graduate credit. A comprehensive final examination will be given to all candidates.

The M.P.A. degree offered at the Capitol Campus at Middletown requires a minimum of 30 graduate credits including a professional master's paper. There is no comprehensive final examination, but an oral defense of the master's paper is required.

The degree is a terminal one, and credits earned in the program may or may not be applicable, even in part, toward a doctorate.

M.R.P.—ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Regional Planning is a professional degree for students interested in a coordinated attack on the problems of community development and resource management. The program is intended to acquaint the student with rational programs of spatial allocation of land uses and facilities, maintenance of cultural and aesthetic values, and legal and governmental techniques for their implementation.

A minimum of 45 graduate credits is required. A minimum of 36 credits is required in planning courses, at least 6 of which will be earned in preparing (1) a problem-oriented thesis, or (2) an individual project report, comparable in quality and scope to a graduate thesis, or (3) a project written in a terminal, integrative course in regional planning.

This degree is also offered at the Capitol Campus.

STUDENT SERVICES

The facilities and services outlined in the following paragraphs are available to graduate students or, in some cases, to a graduate student, his wife, and dependents.

RITENOUR HEALTH CENTER—Located in the central campus area, the Ritenour Health Center is the core of the health service activities and is composed of a dispensary and a hospital. Its facilities are available to full-time graduate students, that is, students registered for 8 or more credits or the equivalent (students holding quarter-time assistantships scheduling 7 to 9 credits, or students holding half-time assistantships scheduling 5 to 7 credits). The outpatient dispensary handles student medical problems from 8:00 a.m. to 11:45 a.m. and from 1:30 p.m. until 4:45 p.m. daily except Saturdays, when hours are from 8:00 a.m. to 11:45 a.m. During other periods, including Sundays and holidays, patients are seen for emergencies only in the Emergency Room of the University Hospital, which is part of the Health Center complex.

The University Hospital is well equipped to handle the more serious illnesses and injuries on an inpatient basis. A sixty-five-bed facility, it is staffed with professional personnel twenty-four hours a day during the school terms. Should the need arise for special medical or surgical treatment—major surgery, for example—the student is transferred to a hospital facility of his choice.

Included in the Health Center facilities are a dental office for emergency dental care, a physiotherapy department, and a pharmacy which has been enlarged and placed in back of the Health Center in order to expand the outpatient clinic.

Hospitalized students will be charged $10 per day during confinement, and a nominal charge will be made for all drugs dispensed to hospital or dispensary patients. A standard laboratory and X-ray fee is charged for examinations done in the Health Center when ordered by physicians other than the members of the Health Center staff. Consultation with or treatment by physicians other than the professional staff at the Health Center is at the student's expense.

The Ritenour Health Center maintains an ambulance service for local transportation of students with nonambulatory illnesses and injuries.

MEDICAID BENEFITS—Graduate students can qualify for most of the benefits that apply to hospitalization and medical treatment under Medicaid. State medical assistance is available upon application to the Office of the Centre County Board of Assistance, Bellefonte, Pa. 16823.

HEALTH SERVICES FOR CHILDREN—Many medical services are available for children under 21 through the State Health Center. The services range from simple immunizations to complicated surgery. Diagnostic study and consultation at the Center are made regardless of the ability to pay. Children may be referred to the Center by physicians or health and welfare agencies. Since many of the services require continual consultation with the physician, referrals must be by physicians located in Centre County. For additional information, consult your doctor, or contact the Health Center at 110 South School Street, Bellefonte, Pa. 16823.

MATERNITY BENEFITS—The Undergraduate Democratic Government Student Medical Plan has been liberalized to include a maternity benefit option. This option is being offered on an experimental basis depending upon the number of applications made. Contact the Student Medical Plan, c/o HMB, Inc., 230 Oliver Building, Pittsburgh, Pa. 15222.

HEALTH INSURANCE PLAN—The University has arranged for a voluntary group Student Accident and Sickness Insurance Plan with a variety of benefits available to graduate students and their dependents, provided the student is eligible for the services of the Ritenour Health Center and pays the cost of the policy and the appropriate premium for the inclusion of dependents.

The plan is set up on a school year basis beginning with the fall term. At this time a representative of the insurance company maintains an enrollment desk in the Hetzel Union Building. An open enrollment is also held near the beginning of the spring term for coverage until the fall term.

Included in the plan is coverage for accidental death or accident medical benefits, hospitalization, laboratory fees, surgery, and doctors' visits up to fixed amounts, plus major medical expense benefits after satisfaction of $100 deductible for each illness. This plan also provides a major medical expense benefit only, but requires the insured to pay the first $500 as a result of sickness or accident.

Full details are available each year through the representative at Hetzel Union Building or through the local representative (telephone area code 814, 238-6725).

INSURANCE PROTECTION WHILE ATTENDING THE UNIVERSITY—The Pennsylvania State University is an instrumentality of the Commonwealth performing its function of education. It is not liable for the negligence of its officers, servants, and employees when in the exercise of public or governmental powers or in the performance of public or governmental duties incident to the general educational work of the University.

Therefore any student who desires insurance protection while in attendance at the University against personal injury and/or against loss of property by fire or theft should arrange personally for whatever insurance seems advisable.

PLACEMENT SERVICE—The University Placement Service, 118A Grange Building, in cooperation with all the colleges and departments of the University, assists both graduate and undergraduate students in finding appropriate employment upon graduation. In addition, services are extended to alumni. Among the services offered are: (1) career counseling concerning career planning, career opportunities, employer characteristics, and employment trends; (2) a library of information about employers, employment trends, and career opportunities; (3) an extended file of employment opportunities for which a student may apply by mail; (4) a listing of summer jobs and internships appropriate to the student's career interests; and (5) conducting of appropriate research. These services are closely coordinated with the Division of Counseling.

Contact is maintained with several thousand employers in education, industry, and government. Information concerning employment opportunities is routinely distributed to all academic departments.

The general placement section concentrates on employment possibilities in industry and government. The educational placement section concentrates on administrative, teaching, and service opportunities in universities as well as in elementary and secondary schools.

RELIGIOUS PROGRAMS—The University seeks to serve the spiritual needs of its students and staff. General responsibility for religious activity on the campus rests with the University Coordinator of Religious Affairs. Individual organizations under the sponsorship of members of the Jewish, Protestant, and Roman Catholic faiths serve the student body. Many other religious organizations, including denominational and interdenominational groups, are active on the campus and in association with local churches.

SELECTIVE SERVICE—A request for deferment must be addressed to the local board by the student himself. The University can supply local boards with information needed in support of a request for deferment.

To have his local board informed of his formal admission to the Graduate School, a student must supply the essential Selective Service information and request the Records Officer to inform the board.

Detailed information concerning Selective Service is available from the Records Officer.

STUDENT AIDS

In every case in which a graduate assistantship, fellowship, grant-in-aid, or scholarship for the next academic year is offered to an actual or prospective graduate student, the student, if he indicates his acceptance before April 15, will have complete freedom through April 15 to submit in writing a resignation of his appointment in order to accept one elsewhere. However, an acceptance given or left in force after April 15 commits him not to accept another appointment without first obtaining formal release for the purpose.

ASSISTANTSHIPS

Approximately 1,900 graduate assistantships are awarded annually. Most of these are half-time, but a limited number of quarter-time and three-quarter-time assistantships are available in some major programs. An appointee may serve as an assistant in classroom or laboratory instruction, or in research or other work.

A prospective student should write directly to the head of his major department or program chairman for information and application forms. Appointments are made upon the recommendation of the department head or program chairman, subject to the approval of a student for an advanced degree program and his admission to the Graduate School. Clear evidence of superior ability and promise is required. Reappointment to an assistantship is based on availability of positions and the quality of the student's work as a graduate assistant. In most departments or major programs the number of appointment renewals is limited. A common policy is to limit eligibility to two calendar years of study for a master's candidate or five total years for a doctoral candidate.

The assistantships vary as follows:

Quarter-Time—The student may schedule 7-9 credits, receives a stipend in the range $318-$600 per term plus a grant-in-aid which covers tuition, will be required to give a maximum of ten hours of service per week for twelve weeks, and will be considered to be following a full-time course of instruction under Selective Service regulations.

Half-Time—The student may schedule 5-7 credits, receives a stipend in the range $630-$1200 per term plus a grant-in-aid which covers tuition, will be required to give a maximum of twenty hours of service per week for twelve weeks, and will be considered to be following a full-time course of instruction under Selective Service regulations.

Three-Quarter-Time—The student may schedule 4-5 credits, receives a stipend in the range $948-$1800 per term plus a grant-in-aid which covers tuition, will be required to give a maximum of thirty hours of service per week for twelve weeks, and will be considered a part-time student.

The credit load limits specified above may be increased or decreased for a specific term by permission of the person to whom the student is responsible for his service assignment, provided the credit load and the service load are properly balanced in each term, and the total credit load over a series of terms is in conformity with the specified limits.

In addition to receiving a grant-in-aid to cover full tuition during the term of appointment, a graduate assistant who is completing three or more consecutive terms of service is entitled to apply for an extra earned grant-in-aid to cover tuition for the succeeding term without service if he is not receiving a scholarship or fellowship from another source during the term. To receive this privilege a student must obtain an

extra earned grant-in-aid form from the head of the department or program in which he has held the assistantship and must follow the instructions on the form in making application.

Graduate assistants may accept concurrent employment outside the University only with the permission from the department head or program chairman. He may not hold concurrent employment with the University other than a Fellowship Supplement.

A graduate assistant pays no fee for the privilege of driving and parking on the campus but is required to comply with student regulations concerning motor vehicles.

FELLOWSHIPS AND TRAINEESHIPS

More than eight hundred fellowships and traineeships are awarded annually. Recipients must be superior students and are frequently required to have completed a certain minimum of graduate work before being eligible for an award. Fellows and trainees carry full-time graduate programs, receive stipends which vary with the awards, and receive grants-in-aid paid by the donors of the awards to provide for all tuition. They may not accept employment during the terms of their appointments (except when stipulated for training purposes), nor are they required to render any service to the University. In some cases a recipient will be expected to limit his research to a broad field specified by the donor. Recipients are required to pay specific charges, such as admission, late registration, change of schedule, and parking fees, and also the thesis binding and microfilming fee unless the latter is paid for by the donor of the award.

COMMONWEALTH OF PENNSYLVANIA RESEARCH FELLOWSHIPS—Intended as a means of encouraging students to conduct research on projects of special application to Pennsylvania, awardees are selected from among Ph.D. candidates who will have passed their comprehensive examination before the start of fellowship tenure on the basis of the usefulness of their research to Pennsylvania and on scholarly promise. These fellowships pay $300/month for three to twelve months plus remission of the dissertation fee. Application forms are available in Room 317 Kern Graduate Building.

GRADUATE SCHOOL FELLOWSHIPS—A small number of fellowships, each paying a stipend of up to $2,520 for the fall, winter, and spring terms and providing a grant-in-aid to cover all tuition charges for these terms, are given by the University and are designated as Graduate School Fellowships. They are available to outstanding graduate students working toward a doctoral degree in any doctoral program, although, ability of applicants being comparable, some preference is given to students majoring in the humanities and social sciences.

Applications should be addressed to the Graduate School Fellowship Office, 317 Kern Graduate Building, and must be received by the fifth Monday of the winter term to be considered for the following year.

ERIC A. WALKER FELLOWSHIPS, FELLOWSHIP SUPPLEMENTS, AND GRANTS-IN-AID—These are open only to students who have been approved for admission but are not yet enrolled in the Graduate School at the time of application. Full fellowships pay $240/month for nine months plus tuition. Grants-in-aid provide only tuition. Supplements are small grants supplementing a graduate assistantship or another fellowship. Application forms may be obtained from the Fellowship Office, 317 Kern Graduate Building, University Park, Pa. 16802, and must be submitted by February 20 to be considered for the following fall. Applicants must arrange to have Graduate Record Examination verbal and quantitative scores sent to this address so as to reach the Fellowship Office by February 20.

FELLOWSHIPS AND TRAINEESHIPS FROM SPECIFIC GRANTS TO DEPARTMENTS AND DIVISIONS BY FOUNDATIONS, INDUSTRIES, AND FEDERAL AGENCIES—At least 230 such awards, with various stipends are granted through individual departments. Information and application forms may be secured from the head of the major department concerned. The specific awards will vary somewhat from year to year, but the following are typical of those which were available for 1971-72.

Amelia Earhart Fellowship—Available to a woman graduate student in aerospace engineering; stipend $2,400.

American Chemical Society Fellowships (2)—Open to graduate students in geochemistry, mineralogy, and solid state science; stipend $2,400.

American Iron and Steel Institute Fellowships (2)—Open to graduate students in geochemistry and metallurgy; stipend $2,400-$4,320.

Armstrong Cork Summer Fellowships in Chemistry (5)—Open to graduate students in chemistry.

Atomic Energy Commission Graduate Traineeships in Nuclear Reactor Operations and Utilization (6)—Open to graduate students in nuclear engineering; stipends comparable to the AEC Special Fellowships.

Brockway Glass Company Fellowship—Available to graduate student in ceramic science whose thesis is in the area of glass science; stipend $3,500-$4,000.

Carborundum Corporation Fellowship—Available to a graduate student in mineral processing; stipend variable up to $3,600.

Chevron Oil Company—Western Division Fellowship in Geology or Geophysics —$2,000 plus tuition and fees, plus $600 dependency allowance for children.

Continental Oil Company Fellowship—Available to a graduate student in chemical engineering; stipend $2,700.

Continental Oil Company Fellowship—Available to a graduate student in petroleum and natural gas engineering for studies in petroleum engineering; stipend $2,280.

Continental Oil Company Fellowship in Petroleum Economics—Available to a graduate student in mineral economics for studies in petroleum economics; stipend $2,280.

Diamond Shamrock Corporation Summer Fellowship—Available to a graduate student in chemical engineering; stipend $750.

du Pont Fellowship—Available to a graduate student in mechanical engineering; stipend $900 per term plus tuition.

du Pont Summer Fellowships (6)—Open to graduate students in chemical engineering; stipend $900.

W. S. Elliott Fellowship—Available to a graduate student who is a Penn State graduate and is interested in engineering research; stipend $1,200.

Ernst and Ernst Fellowship—Available to a master's candidate in accounting; stipend $1,000.

Herman G. and Suzanne G. Fisher Foundation Fellowship—Available to an advanced graduate student in human development and family studies and especially interested in work with young children; stipend $3,500 for tuition and other expenses.

General Foods Fund Fellowships (2)—Open to graduate students with a major in the College of Human Development; stipend for doctoral $3,000, for master's $2,000 for tuition and other expenses.

Gulf Oil Company Fellowship in Petroleum and Natural Gas Engineering—Available to a graduate student for work in petroleum production; stipend $2,400.

Haskins and Sells Foundation Fellowship—Available to a graduate student in accounting; stipend $2,500.

Walter E. Heller Fellowship—Provided by Walter E. Heller & Company, in the amount of $1,000 for a candidate for the degree of Master of Business Administration.

Hill Fellowships for Study in Anthropology or History—Details available from Dean S. F. Paulson of the College of the Liberal Arts, 108 Sparks Building.

Hill Fellowships in History—Available to graduate students in history for the completion of the Ph.D. dissertation; nonrenewable; stipend $3,000.

H. R. Imbt Services, Inc., Fellowship—For graduate work in civil engineering in the field of civil engineering construction; stipend $3,000.

International Lead Zinc Research Organization Fellowship—In support of research on the application of lead and zinc compounds to chemical, ceramic, electrical, and allied industries. Available to two students in ceramic science; stipend $3,000.

International Lead Zinc Research Organization Fellowship—In support of research on the physics and chemistry of lead and zinc compounds. Available to a student in solid state science; stipend $2,540.

Joseph M. Johnston Memorial Scholarship—Available to a student whose program is related to floriculture; stipend variable.

Samuel H. Kress Foundation—Makes available travel grants and research stipends for American students in art history, architecture, and conservation; for doctoral candidates only.

Lubrizol Foundation Fellowship—Available to a graduate student in chemical engineering; stipend $2,700.

National Lead Company, Titanium Alloy Manufacturing Division Fellowship—In support of research on the chemistry and physics of titanium and zirconium compounds of interest to the chemical and ceramic industries; stipend $2,800.

National Steel Corporation Fellowship—Available to a graduate student in metallurgy; stipend $2,880.

Norton Company Fellowship—Available to a graduate student in ceramic science for research on thermal/mechanical properties; stipend $3,000.

Edward Orton, Jr., Ceramic Foundation Fellowship—Available to a student in ceramic science for studies relating to kiln-dried ceramic materials; stipend $2,400.

Owens-Illinois Fellowship—Available to graduate student in ceramic science whose thesis is in the area of glass science and technology; stipend $3,000-$3,600.

Pennsylvania Cooperative Fishery Unit Fellowships (3-4)—Open to graduate students in zoology; stipend $2,400-$2,460.

Pennsylvania Environmental Engineering and Science Fellowships—Available to graduate students in environmental studies; $5,400 for stipends, plus tuition and related fees.

Price Waterhouse Foundation Fellowship—Available to a Ph.D. candidate in accounting; stipend variable up to $5,000.

Proctor and Gamble Company Fellowship—Available to a U.S. citizen who is a graduate student in chemical engineering; stipend $2,700.

Radio Corporation of America Fellowship—Available to a graduate student in electrical engineering; stipend $2,100-$3,000 for nine months. May be supplemented for an additional three months on application.

Refractories Institute—research in field of refractories. Available to student in ceramic science; stipend $3,000.

Rockwell Manufacturing Company Fellowship—Available to a graduate student in mechanical engineering; stipend $900 per term plus tuition.

Sel-Rex Corporation Fellowship—Available to a student in ceramic science.

Shubert Fellowship in Playwriting—Available to a graduate student in theatre arts; stipend $2,500.

Edwin Erle Sparks Dissertation Fellowship in the Humanities (1)—Available to doctoral candidate in the humanities (classics; comparative literature, English, French, German; history; philosophy; religious studies; Slavic languages; Spanish, Italian, and Portuguese; speech); stipend $3,500 plus tuition. Apply to relevant department before February 1.

Edwin Erle Sparks Fellowships in the Humanities (8)—Available to beginning graduate students in the humanities (classics; comparative literature, English,

French, German; history; philosophy; religious studies; Slavic languages; Spanish, Italian, and Portuguese; and speech); stipends $2,400 plus tuition. Apply to relevant department before February 1.

Sprague Electric Company Fellowship—Awarded through the Materials Research Laboratory.

Stackpole Ferrite Fellowship—Available to a graduate student in ceramic science or solid state science; stipend $3,000.

Sun Oil Company Fellowship in Chemistry—Available to the incoming graduate student who is judged to offer the greatest promise for a successful career in chemistry; stipend $3,000.

Texaco Fellowship in Environmental Studies—Available to a graduate student majoring in engineering with environmental emphasis through the Center for Air Environment Studies; stipend $3,000 per year plus tuition.

Union Carbide Fellowship—Available to a graduate student in mechanical engineering; stipend $2,700 per year (three terms) plus tuition.

U.S. Environmental Protection Agency Water Quality Office Traineeships—Open to students in water quality control in civil engineering. Annual stipend $2,400 plus tuition and dependency allowances.

U.S. Office of Education Fellowships—Open to graduate students with undergraduate degree in engineering, physical science, or mathematics who are preparing as technology teachers in technical institutes and junior colleges; stipend $2,400 for 12 months plus an allowance of $500 for each dependent.

U.S. Office of Education Fellowships in Education of Exceptional Children (28)—Open to graduate students being prepared as leadership personnel in the education of the mentally retarded and the emotionally disturbed and in special education administration; stipend $2,200-$3,200 plus dependency allowance. Apply to the head of the Department of Special Education.

U.S. Office of Education Fellowships in Speech Pathology and Audiology: Work with the Speech-Handicapped (5); Work with the Deaf (4)—Open to graduate students specializing in these fields; stipend up to $2,200-$3,200 plus dependency allowance. Apply to the director of the Speech and Hearing Clinic.

U.S. Office of Education Prospective Teacher Fellowships in Engineering Technology (7)—Open to students with baccalaureate degree in engineering, physics, or mathematics who have had two years of experience; stipend $2,400 for 12 months plus dependency allowance of $500 each.

U.S. Office of Education Traineeships in Therapeutic Recreation (6)—Open to graduate students majoring in therapeutic recreation; stipend $1,800 (three terms).

U.S. Public Health Service Air Pollution Special Fellowship (Post-Doctoral)—Available to post-doctoral scholars in the physical sciences, biological sciences, and social sciences; stipend $6,000-$7,000 plus dependency allowance.

U.S. Public Health Service Traineeships—Available through Departments of Anthropology, Biological Health, and Biophysics.

U.S. Public Health Service Traineeships in Air Pollution (26)—Open to selected graduate students in the physical sciences, biological sciences, and social sciences; stipend $3,000-$3,600 plus dependency allowance. Applications and information available through the Center for Air Environment Studies.

U.S. Public Health Service Traineeships in Clinical Psychology (18) Open to selected graduate students in this area of psychology; stipend $1,800-$3,000.

U.S. Public Health Service Traineeships in Microbiology (4)—Open to selected graduate students in microbiology; stipend $2,400-$2,800.

U.S. Public Health Service Traineeships in Nutrition in Public Health (2-4)—Open to first- and second-year students in M.S. program in Nutrition in Public Health; stipend $2,000-$3,600.

U.S. Public Health Service Traineeships in Social Gerontology (12)—Open to selected post-master's graduate students in the social and behavioral sciences; sti-

pend $2,600-$2,800 plus dependency allowance. Apply to director, Program in Adult Development and Aging.

U.S. Public Health Service Traineeships in Verbal Behavior (8)—Open to selected graduate students in this area of psychology; stipend $2,400-$2,800.

U.S. Rehabilitation Services Administration Traineeships in Speech Pathology and Audiology (11)—Open to graduate students specializing in speech pathology and audiology; stipend $2,400-$3,400.

U.S. Rehabilitation Services Administration Traineeships in Therapeutic Recreation (6)—Open to graduate students specializing in therapeutic recreation; stipend $1,800 (three terms).

United States Steel Fellowship—Available to a graduate student in metallurgy; stipend $2,400-$3,600 per year.

U.S. Vocational Rehabilitation Administration Traineeships in Vocational Rehabilitation Counseling (36)—Open to graduate students in counselor education who are specializing in vocational rehabilitation counseling; stipend $1,800-$2,000.

Veterans Administration Internships in Clinical Psychology (5)—Open to selected advanced graduate students in this area of psychology; stipend $3,500-$6,500, not including tuition and fees.

Walter Thomas Memorial Scholarship—Available to a student studying the nutrition of horticultural crops; stipend variable.

Arthur Young and Company Fellowship (1)—Open to a master's degree candidate in accounting from a predominantly black college.

In addition grants are available from governmental agencies, industrial concerns, foundations, and the armed forces for graduate study and frequently for support of investigations of particular problems. Some of these permit full-time study and carry the same exemptions as the fellowships listed above. Detailed information may be secured from departments.

EXTERNALLY SPONSORED FELLOWSHIP AND TRAINEESHIP PROGRAMS—Attention is directed to the following national programs, involving numerous fields of study, with which the University cooperates by providing local administration. (See statement on nondiscrimination, p. 39.)

Atomic Energy Commission Special Fellowships in Nuclear Science and Engineering—These fellowships are available to United States citizens who hold bachelor's degrees in engineering or physical science (chemistry, earth science, mathematics, or physics) and who have completed mathematics through ordinary differential equations. Applicants for first-year fellowships will be required to take the Graduate Record Examinations, designed to test aptitude and achievement, which are administered in January at a large number of centers in the United States and overseas. Before a fellowship appointment becomes effective, the fellow must be granted fellowship clearance by the Atomic Energy Commission and must be accepted by a participating university for study leading to an advanced degree. The deadline for filing applications for fellowships beginning in September is the first of the preceding January. Forms may be obtained from the NSE Fellowship Office, Oak Ridge Associated Universities, Oak Ridge, Tennessee. About 200 will be awarded.

Federal Highway Administration Fellowships—Provided by the Federal Highway Administration, U.S. Department of Transportation, in support of the successful administration of the cooperative highway and safety programs of federal, state, and local governments. Open to engineering graduates for graduate study in highway traffic engineering. Only U.S. citizens are qualified. Fellowships include tuition and living stipend of $3,024 for the nine-month course starting each fall term. Application forms are available from the Bureau of Highway Traffic, Department of Civil Engineering, 212 Sackett Building.

Federal Water Quality Administration Fellowship—Are given to encourage research and training related to the causes, prevention, and control of water pollution

and the management of water quality. Application is made directly to the Training Grants Branch, Washington, D. C. 20242. Fellowships are coordinated through the Graduate School Fellowship Office for those awardees who attend The Pennsylvania State University.

Ford Foundation—320 East 43rd Street, New York, N. Y. 10017—Offers doctoral fellowships for beginning American Indian, Mexican-American, Puerto Rican, and Black students. Each fellowship includes a monthly stipend of $250, tuition, a book and supply allowance, and a dependency allowance. Applications must be submitted by January 10. Dissertation-year fellowships for up to $5,000 are also available for research on the history and culture of these ethnic groups and Asian-Americans. Applications must be submitted through the Graduate School Fellowship Office, 317 Kern Graduate Building, by February 14.

Housing and Urban Development Graduate Fellowships—For the graduate training of professional city planning and urban and housing technicians and specialists; carry stipends of $3,000 per year plus tuition plus $500 per dependent. About 100 are awarded annually in national competitions. Application forms are available from Urban Studies Fellowship Program, Community Development Training Divisions, U.S. Department of Housing and Urban Development, Washington, D. C., 20410, and must be completed and filed by April 15 for study starting the following September.

International University Fellowships in Space Science—These graduate and post-doctoral fellowships are available to foreign nationals who hold the equivalent of master of science or master of engineering degrees and meet graduate student entrance requirements at United States universities. Details on the program will be found in the brochure concerning these fellowships issued by the Office of Scientific Personnel, National Academy of Sciences, Washington, D. C.

National Defense Modern Foreign Language Fellowships—Under Title VI of the National Defense Education Act of 1958, as amended, the U.S. Commissioner of Education allocates to institutions which have approved programs of study in certain languages of critical importance to the United States, and in the cultural areas related to these languages, graduate fellowships for the study of these languages and the related areas. The languages involved in this program are in general those not commonly taught in the United States. French, German, Italian, and Peninsular Spanish are excluded.

Applicants must give reasonable assurance that they will be available after graduate study for teaching a modern foreign language or a related study in a college in the United States or for such other public service as may be specified in the application materials.

In 1972-73 the University awarded four fellowships in Russian language and area studies for majors in Slavic languages, in the Eastern European program for students majoring in Russian, and for those majoring in art history, economics, geography, history, or political science, with emphasis on Eastern Europe but also studying a Slavic language. Write to the head of the department of one of these six graduate programs.

National Science Foundation Graduate Fellowships—The Graduate School cooperates in this program of prestige fellowships requiring outstanding credentials and available in the biological, engineering, mathematical, and physical sciences; anthropology; economics (excluding business administration); geography, history and philosophy of science; political science; psychology (excluding clinical); and sociology (excluding social work). Also included are interdisciplinary programs such as biophysics, geochemistry, genetics, and physiology. These fellowships are used at the university of one's choice. Application is made during the fall to the Fellowship Office, National Academy of Sciences-National Research Council, 2101 Constitution Ave., N.W., Washington, D. C. 20418, which has charge of evaluating applicants for

the Foundation. About 1,000 new awards were made for 1972-73. The stipend is $300/month for three years plus remission of tuition. The application deadline for 1972-73 was November 29, 1971.

Woodrow Wilson Dissertation Fellowships—Awarded by the Woodrow Wilson National Fellowship Foundation for graduate study at the institution of one's choice to outstanding students in the areas of the humanities and social sciences who expect to complete all requirements for their Ph.D. degrees within four years after starting graduate study. A student *may not apply* for these fellowships but must be nominated by a professor in his college. The stipend is $225 per month, plus tuition. Application forms are available from the Fellowship Office, 317 Kern Graduate Building, or from the Woodrow Wilson National Fellowship Foundation, Box 642, Princeton, N. J.

OTHER AIDS

RESIDENT ASSISTANTSHIPS FOR MEN AND WOMEN—A number of appointments are available to graduate students to serve as resident assistants in the undergraduate residence halls. A resident assistant's responsibility is to work for the social, academic, and emotional adjustment of the undergraduate residents. Specialized training and experience in personnel work are helpful, although not essential. These appointments are for three terms (fall, winter, and spring). Remuneration is in the form of room, board, and full in-state tuition. A resident assistant may not hold a fellowship or an additional assistantship during the term of his appointment, nor may he engage in any other form of part-time employment. He may carry 7 to 9 credits per term. Requests for further information and application materials should be addressed to the Division of Residence Hall Programs, 113 Old Main, University Park, Pa. 16802.

GRADUATE RESIDENT ADVISER FOR MEN AND WOMEN—Positions as graduate resident advisers are available to both men and women. The positions are basically half-time, paying a stipend and allowing enrollment of 7 credits per term. Preference is given to persons working for a degree in higher education with specialization in student personnel administration or counselor education. Responsibilities include coordination of programming in one to three buildings of a residence community and various administrative and advising assignments. Those appointed are expected to reside on campus. Further information and application materials are available from the Division of Residence Hall Programs, 113 Old Main, University Park, Pa. 16802.

GRADUATE TUITION GRANTS-IN-AID—Forty grants for full-time study are awarded each year on a term basis, providing for all tuition. They are available to any student on criteria of financial need and academic promise. A recipient is expected to carry a full program of graduate work but may accept employment with the University or another employer not to exceed ten hours per week, provided he reduces his academic load to 8 or 9 credits. Application for renewal of the grant-in-aid may be made for succeeding terms. The value of these grants to Pennsylvanians is $285 per term, and to non-Pennsylvanians, $662 per term. Applications for grants for the winter and spring terms must be filed by the fifth week of the preceding term.

Competition for these grants-in-aid is closed to all students until their third term at the University. Applications should be addressed to the Office of Graduate School Fellowships, 317 Kern Graduate Building, and must be received by March 1 to be considered for the following summer or fall.

PHI KAPPA PHI GRANTS-IN-AID—One or two tuition grants-in-aid in each of spring and summer terms are available for students completing degree requirements

during the term of the award. Application procedures are the same as for Graduate Tuition Grants-in-Aid.

THE RUTH YOUNG BOUCKE GRADUATE FELLOWSHIP—Established from the estate of Ruth Young Boucke, whose husband was for many years a professor of economics, this fellowship is available every other year to an outstanding graduate student on the same basis as the regular Graduate School fellowships, and selection is made by the Graduate School Committee on Fellowships and Awards. The stipend is at least $1,800 for a tenure of three terms plus a grant-in-aid for tuition.

JOHN W. WHITE FELLOWSHIPS—Awarded to two or three graduates of The Pennsylvania State University each year on the basis of scholarship, need, character, and aptitude. The recipients may enroll in any approved college or university. The University Senate Subcommittee on Scholarships and Awards selects recipients by interview from among the top-ranking seniors who plan to attend graduate or professional school.

SCHOLARSHIPS—A number of scholarships furnished by outside agencies and organizations are awarded anually through individual departments. A request for information should be directed to the department head or program chairman in the program of the student's major interest.

LUCRETIA V. T. SIMMONS SCHOLARSHIP—The State College Chapter of the American Association of University Women has established a modest scholarship which is awarded annually to honor an outstanding woman graduate student. The award does not include exemption from tuition. Nominations are made by departments.

LOANS ADMINISTERED BY THE UNIVERSITY—The Director of the Office of Student Aid has charge of all loans administered by the University, for both undergraduate and graduate students. Application forms may be obtained from his office in 121 Grange Building. Funds are available from three sources:

University Loan Funds have been established through the generosity of University organizations, alumni, faculty, staff, and friends. Graduate students without assistantships who are registered for full credit loads may obtain long-term loans, while graduate assistants who are classified as full-time students by the Dean of the Graduate School may qualify only for short-term loans from these funds. Applicants must demonstrate a need for financial assistance in meeting University-related expenses and be United States citizens, except that international students may qualify for short-term loans if they can secure a responsible resident of Pennsylvania as cosigner of the note. The interest on long-term loans does not begin until after graduation and generally is at a low rate for the first two years.

National Defense Education Act Loan Funds are available for United States citizens from the federal government, this act having been expanded in the fall of 1964 to increase the amount allotted to each institution and to increase the ceiling on loans to graduate students to $2,500 per year. The forgiveness of half the loan over a five-year period for those entering teaching has been extended to college teaching and to teaching in private elementary and secondary schools, as well as to teaching in public elementary and secondary schools. Interest at 3 per cent does not start until nine months after the borrower ceases to be a full-time student. Repayment must then be made at the rate of no less than $15 per month.

The Alumni Graduate Student Loan Fund has been established through the efforts of the University Alumni Fund and contributions of Graduate School alumni who have received their bachelor's degrees elsewhere. The Graduate Student Association has also made sizable contributions to it. The purpose of this fund is to assist graduate students on a short-term loan basis in meeting somewhat unexpected financial obligations associated with receiving a degree, such as thesis typing, thesis binding and

microfilming fee, job interview travel, etc. Students who have completed all required credits and are not registered, but are completing their theses and anticipating graduation at the next commencement, may qualify for these loans.

STATE HIGHER EDUCATION LOAN PLANS—A number of states have passed laws which enable them to set up agencies to guarantee loan agreements with commercial banks, enabling cooperating banks in those states to make long-term personal loans to qualifying students to help pay their college or graduate school expenses. This cooperation makes possible lower interest charges and longer repayment periods than are available for ordinary personal loans.

Pennsylvania has established the Pennsylvania Higher Education Assistance Agency for those who have been residents of Pennsylvania for one year prior to filing applications and are accepted for enrollment in approved institutions of higher education. A full-time graduate student may borrow up to $1,500 per year, the total not to exceed $7,500 during the entire period of his post-secondary education. To be eligible, a part-time graduate student must be enrolled for at least 6 credits and is limited to $500 per year. The federal government will generally pay the interest on behalf of the student while he/she is enrolled in school and the first 3 percent of interest while the student is making repayment following graduation or withdrawal from school. Repayment of the principal of the loan is not required until the student leaves or graduates from school. Generally, to be eligible for the interest subsidy, the annual adjusted family income must be below $15,000 per year and the student must be enrolled in an eligible course of study in a nonprofit institution. A list of participating lending institutions is available from all secondary school counselors, school financial aid officers, or the Pennsylvania Higher Education Assistance Agency, Guarantee Loan Program, Towne House, Harrisburg, Pa. 17102.

Residents of other states should inquire of their state education departments regarding the existence of similar plans. Practically all the states of the United States, and the District of Columbia, have such programs.

GIRARD EDU-CHECK PLAN—The University offers to sponsors (including parents) of students the Assured Education Plan, enabling them to pay out of current income, on a monthly basis, University bills for tuition, residence hall room and board, and all other items billed by the University. Life insurance and total and permanent disability insurance are a part of the plan for the sponsor up to his sixty-eighth and sixty-first birthdays, respectively. Payments are handled through the Girard Bank, 2nd and Chestnut Streets, Philadelphia, Pa. 19106. Further information and application forms may be obtained from the Office of the University Bursar, 103 Shields Building. Signed agreements should be received well in advance of registration, since it takes at least three weeks for completion of arrangements.

STUDENT EMPLOYMENT—A student who accepts part-time employment must recognize the time demands of his work schedule and must adjust his academic load accordingly. The Office of Student Employment, 17 Grange Building, offers assistance to students in finding part-time employment in town as well as on the campus. The number of jobs available is limited, and in many cases it is the student who is able to arrange his classes in such a way as to leave free time in the morning or afternoon who is most successful in finding work. Evening jobs are also available for many students. The Office of Student Employment does not hire students, but refers those interested to interviews for jobs if they meet the minimum qualifications set by the employer (qualifications often include hours of availability, special skills, major program, etc.).

The Federal College Work-Study Program, a source of many jobs for students, is coordinated through the above office. Eligibility is determined from the Confidential Financial Statement.

Summer employment catalogs are maintained, including many summer camp job opportunities. During winter and spring terms a number of camp personnel interview

on campus for summer counseling positions. Interviews are scheduled through this office.

The State College Chamber of Commerce also gives assistance to students concerning part-time employment. The Chamber of Commerce, local placement services, and the University Office of Personnel maintain files of positions open to wives of students. Many local residents seek help for baby-sitting, housework, typing, and other general kinds of employment.

A student holding a fellowship, traineeship, or scholarship may not accept employment of any kind for service beyond that specified by his appointment. Graduate assistants may accept concurrent employment outside the University only after obtaining permission from the department head or person in charge of his major program. He may not hold a concurrent appointment with the University other than a Fellowship Supplement.

VETERANS' BENEFITS—The Coordinator of Veterans Affairs has the responsibility of handling all applications for benefits under the various public laws.

Under P. L. 89-358, a student is classified as full-time if he registers for 8 or more credits.

After each term's registration, the number of credits scheduled must be reported to the University Coordinator of Veterans Affairs for enrollment certification to the Veterans Administration.

Recently discharged servicemen not in this area may obtain information on veterans' educational benefits under P. L. 89-358 and its recent revision from the Veterans Administration representatives at their local county courthouses.

Graduate Major Programs of Study

GRADUATE MAJOR PROGRAMS OF STUDY

Administration (Capitol)—M.Adm.
Aerospace Engineering—Ph.D., M.S.
Agricultural Economics—Ph.D., M.S., M.Agr.
Agricultural Education—Ph.D., D.Ed., M.S., M.Ed.
Agricultural Engineering—Ph.D., M.S.
Agronomy—Ph.D., M.S., M.Agr.
American Studies (Capitol)—M.A.
Anatomy (Hershey)—Ph.D., M.S.
Animal Industry—Ph.D., M.S., M.Agr.
Animal Nutrition—Ph.D., M.S.
Anthropology—Ph.D., M.A.
Architectural Engineering—M.S.
Architecture—M.S.
Art—M.A., M.F.A.
Art Education—Ph.D., D.Ed., M.S., M.Ed.
Art History—Ph.D., M.A.
Astronomy—Ph.D., M.S.
Biochemistry—Ph.D., M.S.
Biological Chemistry (Hershey)—Ph.D., M.S.
Biological Science—D.Ed., M.Ed.
Biology—Ph.D., M.S.
Biophysics—Ph.D., M.S.
Botany—Ph.D., M.S.
Business Administration—Ph.D., M.S., M.B.A.
Ceramic Science—Ph.D., M.S.
Chemical Engineering—Ph.D., M.S., M.Eng.
Chemistry—Ph.D., M.S.
Civil Engineering—Ph.D., M.S., M.Eng.
Classics—M.A.
Comparative Literature—Ph.D., M.A.
Computer Science—Ph.D., M.S.
Counselor Education—Ph.D., D.Ed., M.S., M.Ed.
Dairy Science—Ph.D., M.S.
Developmental and Remedial Reading—M.Ed.
Earth Sciences—D.Ed., M.Ed.
*Ecology—Ph.D., M.S.
Economics—Ph.D., M.A., M.Ed.
Education of Exceptional Children—Ph.D., D.Ed., M.S., M.Ed.
Educational Administration—Ph.D., D.Ed., M.S., M.Ed.
Educational Psychology—Ph.D., M.S.
Electrical Engineering—Ph.D., M.S.
Elementary Education—Ph.D., D.Ed., M.S., M.Ed., (Capitol, M.Ed.)
*Engineering Acoustics—Ph.D., M.S., M.Eng.
Engineering Mechanics—Ph.D., M.S., M.Eng.
Engineering Science (U.P., Behrend, King of Prussia, Capitol)—M.Eng.
English—Ph.D., D.Ed., M.A., M.Ed.
Entomology—Ph.D., M.S., M.Agr.
*Environmental Pollution Control—M.S., M.Eng., M.E.P.C.
Extension Education—M.Agr., M.Ed.
Food Science—Ph.D., M.S.
Forest Resources—Ph.D., M.S., M.F.
French—Ph.D., M.A.
Fuel Science—Ph.D., M.S.
General Engineering—M.Ed., M.Eng.
*Genetics—Ph.D., M.S.
Geochemistry—Ph.D., M.S.
Geography—Ph.D., D.Ed., M.S., M.Ed.
Geology—Ph.D., M.S.
Geophysics—Ph.D., M.S.
German—Ph.D., M.A., M.Ed.
Higher Education—D.Ed., M.Ed.
History—Ph.D., D.Ed., M.A., M.Ed.
Home Economics Education—Ph.D., D.Ed., M.S., M.Ed.
Horticulture—Ph.D., M.S., M.Agr.
Human Development and Family Studies—Ph.D., D.Ed., M.S., M.Ed.
Humanities (Capitol)—M.A.
Industrial Arts Education—Ph.D., D.Ed., M.S., M.Ed.
Industrial Engineering—Ph.D., M.S., M.Eng.
Journalism—M.A.
Laboratory Animal Medicine (Hershey)—M.S.
Linguistics—Ph.D., M.A.
Man-Environment Relations—Ph.D., D.Ed., M.S., M.Ed.
Mathematics—Ph.D., D.Ed., M.A., M.Ed.
Mathematics (King of Prussia)—M.Ed.
Mechanical Engineering—Ph.D., M.S., M.Eng.
Medical Technology—M.S.
Metallurgy—Ph.D., M.S.
Meteorology—Ph.D., M.S.
Microbiology—Ph.D., M.S.
Microbiology (Hershey)—Ph.D., M.S.
Mineral Economics—Ph.D., M.S.
Mineral Engineering Management—M.Eng.
Mineral Processing—Ph.D., M.S.
Mineralogy and Petrology—Ph.D., M.S.
Mining Engineering—Ph.D., M.S., M.Eng.
Music—M.A., M.F.A.
Music Education—D.Ed., M.Ed.
Nuclear Engineering—Ph.D., M.S., M.Eng.
Nutrition—Ph.D., D.Ed., M.S., M.Ed.
Nutrition in Public Health—M.S.
Petroleum and Natural Gas Engineering—Ph.D., M.S.
Pharmacology (Hershey)—Ph.D., M.S.
Philosophy—Ph.D., D.Ed., M.A., M.Ed.
Physical Education—Ph.D., D.Ed., M.S., M.Ed.
Physical Science—D.Ed., M.Ed.
Physics—Ph.D., D.Ed., M.S., M.Ed.
*Physiology (U.P., Hershey)—Ph.D., M.S.
Plant Pathology—Ph.D., M.S.
Political Science—Ph.D., M.A.
Poultry Science—Ph.D., M.S.
Psychology—Ph.D., M.S.
Public Administration—M.P.A.
Public Administration (Capitol)—M.P.A.
Recreation and Parks—M.S., M.Ed.
*Regional Planning (U.P., Capitol)—M.R.P.
Religious Studies—Ph.D., M.A.
Rural Sociology—Ph.D., M.S., M.Agr.
Sanitary Engineering—M.S., M.Eng.
*School Psychology—D.Ed., M.S., M.Ed.
Secondary Education—Ph.D., D.Ed., M.S., M.Ed.
Slavic Languages and Literatures—M.A.
Social Studies—M.Ed.
Sociology—Ph.D., M.A.
*Solid State Science—Ph.D., M.S.
Spanish—Ph.D., D.Ed., M.A., M.Ed.
Speech—Ph.D., D.Ed., M.A.
Speech Pathology and Audiology—Ph.D., D.Ed., M.S., M.Ed.
Statistics—Ph.D., M.S., M.A.
Theatre Arts—M.A., M.F.A.
Veterinary Science—Ph.D., M.S.
Vocational Industrial Education—Ph.D., D.Ed., M.S., M.Ed.
Wildlife Management—M.S.
Zoology—Ph.D., M.S.

*Intercollege Graduate Programs

The degrees listed above are the ones normally conferred in each of the designated major programs. Additional professional degrees, including the M.Agr., M.Ed., and M.Eng., have been authorized in many cases and may be offered at the discretion of the department head or program chairman and the Dean of the Graduate School. Thus, the M.Ed. has been authorized for all of the above programs in which a master's degree is conferred provided the program is appropriate to the preparation of teachers.

GRADUATE MAJOR PROGRAMS AND COURSES*

ADMINISTRATION (ADMIN)

DANIEL M. POORE
Chairman, Graduate Program in Administration at Capitol Campus
Middletown, Pa. 17057

Degree Conferred: M.Adm.

Graduate Faculty: Senior Members Lee and Saylor.
Graduate Faculty: Associate Members Brown, Murty, Poore, and Woodruff.

This program is intended to meet the professional needs of practicing and potential administrators. All students must satisfy (1) a series of prerequisites for each option, (2) 15 credits of common core courses, and (3) at least 15 credits of option area course work. Options are currently available in Business Administration, Public Administration, and Engineering Administration. The Business Administration option is intended for those students who desire to pursue an administrative career in any phase of commerce, business, or industry. The Public Administration option is aimed at those students who desire to assume administrative responsibility in institutions, social work agencies, and local, state, or federal government. The Engineering Administration option is a quantitative program in management science and operations research.

The prerequisite requirements are an integral part of the program. Some or all of these requirements may be waived, based on equivalent work previously completed.

For Business Administration, prerequisite courses are required in micro- and macroeconomic analysis, current economic issues (Econ. 404), finite mathematics, calculus, probability and statistics, accounting, financial management, marketing management, and business law.

For Public Administration, prerequisite courses are required in micro- and macroeconomic analysis, current economic issues, finite mathematics, probability and statistics, and adequate preparation in the social sciences.

For Engineering Administration, prerequisite courses are required in micro- and macroeconomic analysis, current economic issues, finite mathematics, calculus, differential equations, linear algebra, probability and statistics, accounting and financial management, and graduation from an accredited undergraduate curriculum in engineering, mathematics, or physics.

For admission to the Master of Administration program, the student must have a baccalaureate degree from an accredited institution. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

The program is offered only at the Capitol Campus.

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* A course abbreviation, a number, and a title designate each course. Course designations and official abbreviations are listed in the left-hand margin just above the first course in each group. The figures in parentheses following the course title show the number of credits which may be granted for that course. In the case of courses with variable credits, the number of credits which may be earned in a single term is determined by the department or program offering the course.

A department or major program may schedule an entire section of a course below the 400 level for fewer credits than the maximum authorized. In 400- and 500-series courses an individual student may schedule fewer credits than the minimum number but in no case more than the maximum number authorized.

All courses listed under graduate major programs may not be required in the particular major.

COURSES*

Econ. 404. Current Economic Issues (3)
Econ. 405. Advanced Economic Analysis (3)
Econ. 419. Case Studies in Labor-Management Relations (3)

Acctg. 504. Seminar in Managerial Accounting (3-6)

Acctg. 511. Financial and Managerial Accounting (3)

Admin. 500. Administrative Theory (3) History, significance and functions of administration, theories of leadership, authority, decision making, rationality, and efficiency.

Admin. 510. Organization Analysis (3) Examination of concepts of human behavior in formal organizations, systems analysis, conceptual models, and decision processes.

Admin. 520. Administrative Models (3) Formulation and solution of decision models for administrative problems. Analysis of decision making under certainty, risk, and uncertainty.

Admin. 540. Administrative Policy Formulation (3) Analysis of administrative problems from a total organization viewpoint. Case studies of actual organizations are used for analysis.

Admin. 550. Program Planning and Evaluation (3) Analysis and evaluation of public programs and systems from the perspectives of policy development and administrative planning and management.

Admin. 551. Administration and the Political Process (3) Analysis of the relationship of administration to the political processes that shape public policy formulation and execution.

Admin. 553-554. Research Methods in Administration (3 each) Examination of research methodologies relevant to public administration. Student independently develops and executes a significant research project. Prerequisites: Admin. 500, 551, and four option courses.

Admin. 560. Sampling Theory and Practice (3) Study of scientific method of obtaining representative samples, collection of information, techniques of estimation. Prerequisite: Math. 315.

B.Log. 538. Logistics Systems Management (3)

Fin. 531. Financial Management (3)

I,B. 501. The International Environment (3)

I.E. 508. Operations Research I (3)

I.E. 509. Operations Research II (3)

I.E. 510. Mathematical Programming (3)

Mgmt. 510. Operations Management (3)

Mgmt. 540. Personnel Management (3)

Mktg. 500. Marketing Management (3)

* Course descriptions not given below will be found under the designated field of study.

Mktg. 530. Consumer and Market Behavior (3)

Pl.Sc. 575. Government Manpower Management (3)

Pl.Sc. 576. Government Fiscal Decision Making (3)

Q.B.A. 501. Advanced Business Statistics (3)

Q.B.A. 570. Management Science: Implementation and Control (3)

AEROSPACE ENGINEERING (AERSP)

Barnes W. McCormick, *Head of the Department*
233 Hammond Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Arndt, Holl, Lakshminarayana, Lancaster, Lumley, McCormick, Şevik, and Tennekes.

Graduate Faculty: Associate Members Allen, Eisenhuth, Kaplan, Phillips, Sherman, and York.

Opportunities are available for graduate study in the following areas: low-speed aerodynamics, V/STOL aircraft, turbulence, geophysical fluid dynamics, astrodynamics, turbomachinery, plasma dynamics, rarefied gas dynamics, hydrodynamics, stability and control of aerospace vehicles, aeroelasticity, and aerospace structures.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by an intermediate knowledge of two foreign languages, by substitution of courses from other designated areas for one of these languages, or by a comprehensive knowledge of one foreign language.

The entering student must hold a bachelor's degree in physical science, mathematics, or engineering and may be required to complete (without degree credit) undergraduate course work in fluid and solid mechanics and intermediate mathematical analysis, if he has not already done so. Students with a 2.70 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.70 grade-point average may be made for students with special backgrounds, abilities, and interests.

AEROSPACE ENGINEERING (AERSP)

401a,b,c. Aerospace Engineering Projects (1-12)
405. Experimental Methods in Aerospace Engineering (3)
407. Aerodynamics of V/STOL Aircraft (3)
409. Advanced Aerospace Structural Mechanics (3)
410. Aerospace Propulsion (3)
411. Aeroelasticity (3)
412. Turbulent Flow (3)
413. Stability and Control of Aircraft and Missiles (3)
415. Physical Gas Dynamics (3-6)
416-417. Aerospace Design and Thesis (2 each)
420. Principles of Flight Testing (3)
421. (M.E. 421) Intermediate Viscous Flow (3)
425. Theory of Flight (3)
430. Space Propulsion and Power Systems (3)

444. Noise Pollution of Fluid Dynamic Origin (3)
450. Orbit and Attitude Control of Spacecraft (3)

503. Electromagnetically and Chemically Active Flows (3) Flow of media which may be conductive, permeable, ionizable, or otherwise capable of interacting with imposed or self-generated fields.

504. Aerodynamics of V/STOL Aircraft (3) Jet wings, high lift devices, propellers and ducted propellers, circulation and boundary layer control, unsteady airfoil theory. Prerequisite: Aersp. 407.

505. Aero- and Hydroelasticity (3) Interaction of elastic systems having several degrees of freedom with fluid flows in various configurations.

506. Cavitation (3) Flow regimes, dynamics of cavitation, prediction of the minimum pressure in the fluid, scale effects, effect of surface irregularities.

507. Theory and Design of Turbomachinery (3) Theory and principles of machinery design: compressors, turbines, pumps, and rotating propulsors; opportunity to work out design examples.

508. Foundations of Fluid Mechanics (3) Mathematical review, fluid properties, kinematics, conservation laws, constitutive relations, similarity principles, the boundary layer, inviscid flow, vorticity dynamics, wave motion.

509. Dynamics of Ideal Fluids (3) Irrotational flow theory, two-dimensional and axisymmetric flows, airfoil theory, complex variables, unsteady phenomena; flow with vorticity, finite wing theory. Prerequisite: Aersp. 508.

510. Compressible Flow (3) One-dimensional motion, shock waves, flow in nozzles, two-dimensional flow, airfoil theory. Prandtl-Meyer flow, method of characteristics.

511. Aerodynamically Induced Noise (3) Review of fluid mechanics. General theory of aerodynamic sound. Noise radiation from jets, boundary layers, rotors and fans. Structural response. Prerequisite: Aersp. 412.

512. Viscous Flow (3) Stress-deformation relations; Newtonian fluids, Navier-Stokes equations; exact, asymptotic laminar solutions; instability, transition; similitude and turbulent boundary layer.

514. Stability of Laminar Flows (3) The stability of laminar motions in various geometries as influenced by boundary conditions and body forces of various kinds.

515. Foundations of Turbulence (3) The mathematics underlying turbulence theory: descriptions, kinematics of stochastic fields; techniques of solution of linear and some nonlinear problems.

516. Homogeneous Turbulence (3) Dynamics: production, spectral transfer, dissipation, decay of energy; similarity theories.

517. Inhomogeneous Turbulence (3) Dynamics: similarity, structural hypotheses; spatial, spectral budget of energy in a number of classical flows.

518. Dynamics and Control of Aerospace Vehicles (3) Dynamical problems of aircraft and missiles including launch, trajectory, optimization, orbiting, reentry, stability and control, and automatic control. Prerequisite: Aersp. 413 or 450.

550. Astrodynamics (3) Applications of classical celestial mechanics to space flight planning. Determination and construction of orbital parameters by approximation methods. Perturbation techniques. Prerequisite: Aersp. 450 or Astro. 460 or E.Mch. 410 or Phys. 419.

AGRICULTURAL ECONOMICS (AG EC)

LEE M. DAY
Head of the Department of Agricultural Economics and Rural Sociology
6A Weaver Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members Barr, Becker, Bennett, Brandow, Butz, Day, Frey, Gamble, Hutton, Jansma, Madden, McAlexander, Partenheimer, Pasto, Pierce, Stemberger, and Trotter.

Graduate Faculty: Associate Members Epp, Hallberg, Herrmann, Holt, and Schutjer.

The graduate program emphasizes economic theory and analytical techniques in the fields of farm management, production economics, agricultural marketing, resource economics, agricultural policy and prices, and in international agricultural trade and development.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by either (1) mastering one foreign language or (2) passing three graduate courses outside the major and minor fields having communications value.

The entering student in the master's program should have as prerequisites 3 credits in agricultural economics, 3 credits in economics, and 3 additional credits in either agricultural economics or economics. If a student lacks some of the prerequisites, he may take them without graduate credit during the early part of his master's program.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

AGRICULTURAL ECONOMICS (AG EC)

407. ADVANCED FARM MANAGEMENT (3) *Mr. Partenheimer*
410. AGRICULTURAL FINANCE AND APPRAISAL (3) *Mr. Holt*
420. AGRICULTURAL PRICES (3) *Mr. Bennett*
421. LAND ECONOMICS (3) *Messrs. Frey and Gamble*
422. LAND AND WATER RESOURCE POLICY (3) *Mr. Jansma*
450. INTERNATIONAL AGRICULTURAL TRADE AND DEVELOPMENT (3) *Mr. Schutjer*
460. INDUSTRIAL ORGANIZATION IN FOOD PROCESSING AND DISTRIBUTION (3) *Mr. Brandow*
461. DECISION MAKING IN AGRICULTURAL MARKETING FIRMS (3) *Mr. Stemberger*

500. SEMINAR IN AGRICULTURAL ECONOMICS (1-6) Review of current literature and problems.

504. SEMINAR IN AGRICULTURAL POLICY (3) Analysis of farm prices, income consequences for producers and consumers, and effects on resource use; evaluation of policy, considerations in policy making. Prerequisites: Ag.Ec. 420, Econ. 405. Odd years. *Mr. Brandow*

505. ADVANCED AGRICULTURAL STATISTICS (3) Multiple correlation, curve fitting, analysis of variance, and other techniques applicable to the rural social sciences. Prerequisite: 3 credits in statistics. *Mr. Bennett*

507. SEMINAR IN FARM MANAGEMENT (1-6) Special problems relating to organization and operation of the farm business. Prerequisites: Ag.Ec. 6, Econ. 14.

509. Concepts of Econometric Theory (3) Concepts underlying the application of econometric methods to economic problems; identification and multiple equation models; hypothesis testing and decision theory. Prerequisites: Econ. 502, 503.

514. Survey Research Techniques in Agricultural Economics (3) Survey methods and design of samples for obtaining economic data from business-unit and household populations. Prerequisite: Ag. 400. Odd years. *Mr. Bennett*

515. Economic Problems in the Marketing of Dairy Products (3) Economic problems as they are encountered in the process of marketing; particular attention to governmental regulation in pricing and marketing. *Mr. Pierce*

520. Farm Price Analysis (3) Econometric analysis of prices, production, and utilization of farm products; review of research in this field. Prerequisites: Ag.Ec. 420, 505; Econ. 405. Even years. *Mr. Hallberg*

524. Resource Economics (3) Economic aspects of resource use and development: economic growth, land-use planning and control, conservation, resource investment criteria and policies. Prerequisite: Ag.Ec. 421 or 422. *Mr. Epp*

525. Research Methods in Rural Social Sciences (2) Scientific method in planning and conducting research. Prerequisite: 9 credits in social sciences.

527. Seminar in Applied Quantitative Methods (1-4)
Messrs. Hallberg and Partenheimer

534. Agricultural Production Economics (2) Economic theory applied to agricultural production problems: resource combinations, firm size, uncertainty and expectations, aggregate aspects of production, technological change. Prerequisite: Econ. 502.

535. Seminar in Agricultural Marketing (2)

550. Food Consumption Economics (3) Demand theory and research methods applied to the market for foods. *Mr. Herrmann*

571. Seminar in Land and Water Resource Economics (3) Critical review of research in resource economics; consideration of special topics in resource use.
Mr. Jansma

AGRICULTURAL EDUCATION (AG ED)

David R. McClay, *Head of the Department*
102 Armsby Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members McClay, Stevens, and Stinson.
Graduate Faculty: Associate Members Anthony, Curtis, and Hoover.

Graduate programs emphasize the professional improvement of teachers. They provide advanced preparation for employment in administration, supervision, teacher education, and research in agricultural education and related fields. A minor may be taken in an area of agricultural science, technology, business, or in general studies. Programs may include courses needed for certification in other fields of education.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by an intermediate knowledge of two foreign languages, by substitution of courses from other designated areas for one of these languages, or by a comprehensive knowledge of one foreign language.

Prerequisite to admission is a minimum of 18 credits in professional education courses or certification as a teacher of agriculture. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

AGRICULTURAL EDUCATION (AG ED)

400v. Educational Programs in Agriculture for Developing Countries (3)
418v. Survey of Vocational Education in Agriculture (1-4)
420v. Instructional Media in Agriculture (1-6)
422v. Supervision of Vocational Education in Agriculture (1-4)
424v. Occupational Guidance in Agricultural Industry (1-4)
426v. Adult Education in Agriculture (1-4)
434v. Agricultural Developments (1-6)

501v. Agricultural Education in the United States (1-3) Historical development, social and philosophical foundations, and current status in relation to the total vocational-technical education program.

502v. Teaching Agriculture (1-3) Vocational education objectives, learning theory, class instruction, cooperative occupational experience, and evaluation.

503v. Research in Agricultural Education (1-6 per term) Individual study problems in various phases of agricultural education, such as evaluation of teaching, teaching procedures, and teacher preparation.

504v. Agricultural Education Seminar (1 per term)

508v. Administration and Supervision of Agricultural Education (1-3) Administration of state and district systems of vocational-technical education; supervision of teachers of agriculture.

509v. Teacher Education in Agriculture (1-6) Organization and administration of university programs of teacher education in agriculture, including preservice preparation, continuing education, research, and other services.

520v. Scientific Method in the Study of Agricultural Education (1-4) Methods of procedure in investigation and experimentation in education, accompanied by a critical examination of studies made in agricultural education.

521v. Scientific Method in the Study of Agricultural Education (1-4) Continuation of Ag.Ed. 520v; emphasis upon statistical techniques for students' individual problems.

524v. Program Development in Agricultural Education (1-3) Analysis of occupational needs of students and employment prospects; organization of courses of study and other activities of teachers.

530. Agricultural College Teaching (3) Selection and organization of subject matter for specific courses, methods of learning, teaching devices, techniques of teaching, and measurements of results of teaching.

AGRICULTURAL ENGINEERING (AG E)

FRANK W. PEIKERT, *Head of the Department*
250 Agricultural Engineering Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Aldrich, Mohsenin, Peikert, and Persson.
Graduate Faculty: Associate Members Bartlett, Keppeler, Kjelgaard, Morrow, Myers, Schroeder, and Stephenson.

Graduate programs are available in the areas of physical properties of agricultural materials; plant and animal environmental engineering; agricultural processing and food engineering; agricultural mechanization with emphasis on forage, fruits, and vegetables; rural sanitation and conservation engineering; and computer technology applied to agricultural engineering problems.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by either (1) 9 credits of courses in humanities and social science or (2) a foreign language.

Excellent facilities, including equipment and instrumentation, are available for research in the designated areas. Among the special facilities are freeze-drying equipment for drying by sublimation, controlled environmental chambers, plant growth structures for modified atmosphere, a general purpose analog computer, and a laboratory for research on mechanical and rheological properties of agricultural materials. Laboratories are available with universal testing machines, equipped with accessories such as programmers and environmental chambers; a polariscope for photoelastic stress analysis; and acoustical and light reflectance instrumentation for research on the physical and rheological properties of agricultural materials.

Prerequisite to major work is the completion of an undergraduate major in engineering. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

AGRICULTURAL ENGINEERING (AG E)

400. AGRICULTURAL ENGINEERING PROBLEMS (1-7)
401. FARM MECHANICS FOR TEACHERS OF VOCATIONAL AGRICULTURE (1½-9)
402. FUNCTIONAL DESIGN OF AGRICULTURAL STRUCTURES (3)
403. PHYSICAL PROPERTIES OF AGRICULTURAL MATERIALS (3)
404. AGRICULTURAL MACHINERY (3)
405. AGRICULTURAL PROCESS ENGINEERING (3)
407. SOIL WATER ENGINEERING (3)
408. INSTRUMENTATION FOR AGRICULTURAL PRODUCTION AND PROCESSING (3)
409. AGRICULTURAL SYSTEMS ENGINEERING (3)
410. POWER FOR AGRICULTURAL SYSTEMS (3)
412. PHYSICAL PROCESSES IN FOOD MANUFACTURING I (3)
413. PHYSICAL PROCESSES IN FOOD MANUFACTURING II (3)
414. PHYSICAL PROCESSES IN FOOD MANUFACTURING III (2)
420. SEMINAR (1)
423. PHYSICAL AND RHEOLOGICAL MEASUREMENTS ON BIOMATERIALS (3)

500. ADVANCED ELECTRO-AGRICULTURE (1-6) Investigations in the application of electrical energy to processing, storing, and handling agricultural products. Seminar, written reports.

501. Advanced Farm Machinery (1-6) Application of agricultural engineering principles to design and operation of farm machinery. Prerequisite: Ag.E. 410.

502. Farm Structures Problems (1-6) Analysis of farm structures design problems.

503. Physical Properties of Plant and Animal Products (3) Physical characteristics; mechanical, rheological, thermal, electrical, and optical properties in relation to handling, storage, processing, and quality evaluation.

505. Experimental and Applied Instrumentation (4) The theory and application of electronics for instrumentation and experimental research.

507. Problems in Soil Water Engineering (1-6) Analysis of engineering problems relating to irrigation, drainage, or erosion control.

508. Advanced Problems in Farm Mechanics (1-15) Problems in farm shop practice and agricultural engineering related to the farm mechanics program of vocational education in agriculture. Prerequisites: Ag.E. 8, 14; or teaching experience in farm mechanics.

509. Research in Agricultural Engineering (1-4)

520. Agricultural Engineering Seminar (1-3) Reports on research and special topics.

AGRONOMY (AGRO)

James L. Starling, *Head of the Department*
117 Tyson Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members Baker, Barnes, Cleveland, Cunningham, Duich, Fortmann, Harrington, Heald, Hill, Hunter, Jung, Kardos, Kendall, Marshall, Matelski, McKee, Petersen, Richer, Starling, Thomas, and Washko.

Graduate Faculty: Associate Members Bollag, Cole, Fritton, Hall, L. Johnson, M. Johnson, Marriott, Pfeifer, Ranney, Risius, Shenk, and Waddington.

Areas of specialization include soil chemistry; soil conservation; soil classification; soil fertility; soil mineralogy; soil physics; the genetics and breeding of corn, small grains, and forage plants; forage management; turf management; potato culture; tobacco culture; weed control; and ecology of crops and pastures.

The communication and foreign language requirement for the Ph.D. degree is a reading knowledge of one foreign language, which may be met through courses or examination.

Prerequisites for major work in agronomy vary with the area of specialization, but basic courses in chemistry, mathematics, physics, and biological sciences are required. Students who lack some of the course prerequisites may be admitted but are required to take the prerequisite courses without degree credit.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

AGRONOMY (AGRO)

411. Breeding of Field Crops (3) *Mr. Johnson*
415. Soil Morphology, Mapping, and Classification (3) *Mr. Petersen*
416. Soil Genesis (3) *Mr. Ranney*

417.	Forest Soils (3)	*Mr. Ciolkosz*
419.	Soil Properties (4)	*Mr. Baker*
422.	Soil Conservation (3)	*Mr. Cunningham*
423.	Pasture and Grassland Management (3)	*Mr. Washko*
424.	Fertilizer Technology (3)	*Mr. Marriott*
425.	Principles of Field Crop Production (3)	*Mr. Pfeifer*
431.	Soil Fertility and Management (3)	*Mr. Marriott*
438.	Principles of Weed Control (3)	*Mr. Hartwig*
490.	Agronomic Problems (1-6)	*Mr. Washko and Staff*

501. Advanced Soil Fertility (4) Interpretation of fertility experiments and diagnosis of soil-plant relationships through field appraisal, analysis, and plant symptoms. Prerequisites: Agro. 431, Biol. 441. *Mr. Hunter*

503. Agronomy Seminar (1) Weekly meeting where papers and discussions will be presented by students and staff members.

506. Soil Chemistry (4) Analyses of important chemical and biochemical reactions occurring in soils, conditions which control these reactions and their importance in soil genesis and plant growth; laboratory work in the more typical and significant analytical procedures; lectures, review of current literature, and practicum. Prerequisites: Agro. 419; Bioch. 425 or Chem. 451. *Mr. Baker*

507. Soil Physics (4) Physical properties of the soil; factors affecting them; their measurements, evaluation, and influence in determination of soil productivity. Prerequisites: Agro. 419, Bioch. 425, Phys. 215. *Mr. Kardos*

509. Genetics of Crop Plants (3) Inheritance in crop plants with particular reference to factor interaction, genetic aspects of linkage and crossing-over, quantitative inheritance, and heterosis. Prerequisite: Biol. 422. *Mr. Cleveland*

510. The Application of Cytogenetics to Plant Breeding (3) Cytogenetics, including chromosome structure and behavior, chromosome alterations, polyploidy, interspecific hybridization, and their applications to plant breeding. Prerequisite: Biol. 422. *Mr. Cleveland*

512. Field Plot Technique (4) Ramifications of analysis of variance techniques; combining and analyzing data from several experiments; selection of valid error terms. Prerequisite: Stat. 200 or Ag. 400. *Mr. Risius*

516. Humus (2) Origin and chemical nature of soil organic matter, its importance in soil processes, and its decomposition. Prerequisites: Agro. 419, 431. *Mr. Richer*

517. Farm Crops Ecology (3) Ecological factors affecting growth and development of farm crops with particular reference to effects of altered environment and management practices. Prerequisites: Agro. 28, Biol. 441. *Mr. McKee*

518. Growth and Management of Forage Crops (3) Factors affecting growth and development of forage crops with particular reference to effects of environment, defoliation, and management practices. Prerequisites: Agro. 423, Biol. 441. *Mr. McKee*

519. The Nature of Soil Minerals (3) Modern methods for identification of the constituent minerals of soils and their relation to soil classification and agricultural practices. Prerequisites: Agro. 419, G.Sc. 23. *Mr. Johnson*

545. The Appligation of Statistics to Field Experiments (4) Use of advanced experimental designs in planning, analyzing, and interpreting experiments; includes lattice designs, factorials, confounding, simple and multiple covariance techniques. Prerequisite: Agro. 512. *Mr. Starling*

*550. Agronomic Problems (1-12) Provides training in selected areas of agronomy by means of supervised investigations or studies.

582. Seminar in the Breeding and Genetics of Farm Crops (1 per term)

AMERICAN STUDIES (AM ST)

Irwin Richman, *In Charge of Graduate Program in American Studies*
The Capitol Campus, Middletown, Pa. 17057

Degree Conferred: M.A.

Graduate Faculty: Senior Members Lear, Richman, Tischler, and G. Wolf.

Graduate Faculty: Associate Members Anderson, Eisenstein, Knight, McAree, and M. Wolf.

This program emphasizes the study of American society as a whole, not as interpreted by a single discipline, but in the larger context of a culture. The purpose of the program is to provide the student with the opportunity to acquire knowledge and understanding within any of the following areas: ethnic composition and demographic problems of the American people; regional characteristics; the technological base of American civilization; economic, political, and social institutions; the media of communication; artistic expression, particularly in art, architecture, literature, and music; philosophy and values; and the dynamics and interrelationships of all of these.

The student is required to take a minimum of 30 credits, including at least 18 credits in the 500 series. A maximum of 24 of these 30 credits shall be taken within the program area. An original, scholarly master's paper or creative production initiated by the student, supervised by an appropriate professor, and judged by a committee is required. One to six credits can be accumulated during work on the master's production.

For admission, a student must have received a baccalaureate degree from an accredited institution, earned under residence and credit conditions for the master's program. Social sciences or the humanities are not required as prerequisites, though it is anticipated that students will have had work in these areas. The application, transcripts, and a letter outlining personal goals and reasons for applying for the program should be sent directly to the Graduate Office, The Capitol Campus, Middletown, Pa. 17057.

REQUIRED COURSES

Am.St. 500. Theory and Methods (3) Study of the methods and materials of American Studies scholarship, compilation of bibliographies, the writing of scholarly papers, and proper documentation.

Am.St. 580. Production in American Studies (1-6) An original and independent exploration of some area of American Studies.

APPROPRIATE COURSES may be taken from the following list and from 500-level courses in other fields with the concurrence of the student's adviser.

Am.St. 511. Pivotal Books (3) Exploration of a number of books which have been particularly influential in shaping thinking about American civilization.

Am.St. 530. Material Culture (3) Consideration of the techniques for studying material culture and of historical and regional patterns of material culture in America.

* Credits 1-6 per term.

Am.St. 533. American Civilization in the Eighteenth Century (3) Detailed investigation of specific topics in eighteenth-century American civilization.

Am.St. 534. American Civilization in the Nineteenth Century (3) Representative interdisciplinary investigation of social, historical, economic, and aesthetic forces predominant in nineteenth-century America.

Am.St. 535. American Civilization in the Twentieth Century (3) Detailed investigation of specific periods or topics in twentieth-century American civilization.

Am.St. 569. American Science and Medicine Prior to the Civil War (3) An exploration of how scientific and medical thought mirrors the emergence of American culture.

ADDITIONAL COURSES may be taken from the following list and from 400-level courses in other fields with the concurrence of the student's adviser.*

Am.St. 401. Foundations of American Civilization (3)
Am.St. 431. The American Character (3)
Am.St. 442. American Folklore (3)
Am.St. 445. American Philosophy (3)
Am.St. 451. Civil War and Reconstruction (3)
Am.St. 452. The American Renaissance (3)
Am.St. 453. The Gilded Age and the Progressive Impulse (3)
Am.St. 454. America's Political Parties (3)
Am.St. 455. Realism and Naturalism in American Society (3)
Am.St. 456. Mass Culture: The Popular Arts in America (3)
Am.St. 457. Immigrants and Americans (3)
Am.St. 458. Contemporary America (3)
Am.St. 459. America's Coming of Age 1914-1939 (3)
Am.St. 460. American Art and Architecture (3)
Am.St. 463. American Music (3)
Am.St. 470. Regionalism in America (3)
Am.St. 480. Museums and Culture (3)
Am.St. 491. Senior Seminar in American Culture (3)
Am.St. 496. Independent Study (3)
So.Sc. 402. Studies in American Society (3)
So.Sc. 403. Contemporary U.S. Foreign Policy (3)
So.Sc. 470. The Presidency and the Executive Process (3)

ANATOMY (ANAT)

Bryce L. Munger, *Chairman of the Department*
The Milton S. Hershey Medical Center

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Baird, Ha, Munger, and B. Pubols.
Graduate Faculty: Associate Member L. Pubols.

The graduate program emphasizes the general areas of gross anatomy, histology/cytology, neuroanatomy/neurophysiology, or appropriate combinations of these areas.

*Descriptions of these courses may be found in *The Capitol Campus Catalog.*

Approaches offered include morphological (descriptive, comparative, developmental), functional (physiological, chemical), and experimental. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

A bachelor's degree reflecting a reasonable background in zoology or biology, mathematics, and chemistry is required. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Applicants must provide complete transcripts and two letters of recommendation. Scores from the Graduate Record Examination and a personal interview are desirable.

This program is offered only at The Milton S. Hershey Medical Center.

ANATOMY (ANAT)

501. Gross Human Anatomy (3) Macroscopic organization of the extremities and head and neck with emphasis on anatomical individuality, functional significance, and clinical correlations.

502. Gross Human Anatomy (3) Macroscopic organization of the abdomen, thorax, and pelvis with emphasis on anatomical individuality, functional significance, and clinical correlations.

505. Microscopic Anatomy (3) Microscopic organization of tissues and cells; interrelationships of cells; chemical and functional specializations of cells.

510. Neurobiology (3) Morphology and function of the sense organs, general organization of the brain, and physiological studies of central nervous system function.

512. Human Embryology (2) Detailed study of normal development and physiology of the embryo and fetus; attention to developmental anomalies and fertilization problems.

530. Dissection (2-4) Individual dissection of a particular region of the body, study of the pertinent literature, and preparation of a report.

535. Submicroscopic Anatomy (3) Current literature on molecular and micellar organization of cells and tissues in diverse systems; application of interference and electron microscopy.

540. Seminar (1 per term) Student and staff presentations designed to evaluate current research developments in anatomy.

542. Comparative Neurology (3) A study of comparative aspects of central nervous system organization as related to phylogenetic development. Prerequisite: Anat. 510.

543. The Peripheral Nervous System (3) A study of the somatic sensory and motor systems. Prerequisite: Anat. 510.

545. Comparative Vertebrate Otology (3) Evolution and principles of the auditory system demonstrated by comparison of structures in ears of vertebrates; independent study expected.

550. Seminar in Quantitative Optics (3) Study of the various types of light microscopy instruments and application of these tools to quantitative measurements in biological systems. Prerequisite: Anat. 505.

570. Special Topics (1-6) Introduction of students to the research laboratory and scholarly pursuits of members of the staff; credit arranged by consultation.

590. Research Problems (1-12) Individualized research conducted by students in departmental laboratories. The program and credits to be arranged by consultation.

ANIMAL INDUSTRY (A I)

B. R. Baumgardt
Head of the Department of Animal Science
325 Animal Industries Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members Baumgardt, Cowan, Gobble, Long, Sink, and Wilson.

Graduate Faculty: Associate Members Merritt, Sherritt, and Ziegler.

A student may specialize in animal breeding, feeding, management, and meat science. The communication and foreign language requirement for the Ph.D. degree may be satisfied by proficiency in either one foreign language or communications skills (technical writing and speech).

For admission the student must complete an undergraduate major in animal science or a closely related field. Students who lack some of the course prerequisites may be admitted but are required to take the prerequisite courses without degree credit. Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests.

ANIMAL INDUSTRY (A I)

400. Special Topics (1-6)
405. Meat Animal Management (4)
421. Science of Meat (3)
423. Advanced Livestock Selection (2)
424. Animal Industry Seminar (1)
431. Advanced Meat Selection and Grading (2)

501. Pedigree Study (1-6) Research work in breed study history, and analytical study of breed pedigrees, and a complete survey of the herd, flock, or stud book.

502. Research in Meats (1-6 per term) Investigation of methods for handling, cutting, processing, freezing, and curing meat and meat products. Prerequisite: A.I. 421.

505. Advanced Animal Breeding (1-5) Special problems in animal genetics as applied to breeding and improvement of horses, cattle, sheep, and swine. Prerequisite: An.Sc. 322.

510. Animal Science Research Methods (3) Application of scientific method; experimental design and procedures; analyzing, interpreting, and reporting research results. Prerequisite: Ag. 400.

514. Animal Growth and Development (3) Animal life cycles; nature of growth and development; effects of biological, environmental, social, and psychological variants; homeostasis and organismic theory. Prerequisites: 3 credits in biochemistry and 3 credits in physiology.

Note: *See Animal Science under "Other Elective Graduate Courses." Also see Food Science.*

ANIMAL NUTRITION (A NTR)

B. R. Baumgardt
Chairman of the Committee on Animal Nutrition
325 Animal Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Baumgardt, Buskirk, Cowan, Gobble, Hartsook, Hershberger, Kesler, Leach, Long, McCarthy, Mendez, and Mueller.

Graduate Faculty: Associate Members Kollias, Martin, Scholz, and Shellenberger.

This is an interdepartmental graduate program designed to enable students to obtain thorough training in animal nutrition. The program is under the direction of a committee composed of graduate faculty members of the departments of Animal Science, Dairy Science, Poultry Science, Veterinary Science, and the Human Performance Research Laboratory. Programs are offered in ruminant and nonruminant nutrition, including: physiology of nutrition; nutritional requirements for productive functions; metabolism of carbohydrates, lipids, proteins, vitamins, and minerals; and regulation of food intake and other metabolic functions.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign languages.

Undergraduate preparation should include organic and analytical chemistry, physics, biology, and mathematics. Students may be admitted with limited deficiency, but are required to make up undergraduate deficiencies without graduate credit.

Students should have an appropriate background and a 3.00 average in the major area and in related sciences for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum requirements may be made for students with special backgrounds, abilities, and interests.

The following nutrition courses are offered by participating departments, and their descriptions may be found under the listings of the respective departments: D.Sc. 511, Pty.Sc. 502. Courses related to animal nutrition can be found under the following listings in this bulletin: Animal Industry, Biochemistry, Dairy Science, Nutrition, Physiology, Poultry Science, and Veterinary Science.

ANIMAL NUTRITION (A NTR)

400. Nutrition and Feed Technology (3)
401. Physiology of Nutrition (3)
402. Energy and Protein Metabolism (3)

505. Ruminology (3) Physiological, biochemical, and microbiological activities occurring within the rumen and the relation of rumen function to animal response. Prerequisites: at least one course in each of the following areas: animal nutrition, physiology, microbiology, and biochemistry.

Note: *See Animal Science listing under "Other Elective Graduate Courses."*

ANTHROPOLOGY (ANTHY)

Warren T. Morrill
Head of the Department
409 Social Sciences Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Baker, Escobar, Hunt, Matson, Morrill, and Sanders.
Graduate Faculty: Associate Members Michels and Nydegger.

The master's program is designed to train students in general anthropology. The doctoral program is structured to train students in the following areas of specialization: new world archaeology, middle eastern archaeology, archaeological methodology, physical anthropology with special emphasis on human ecology, cultural ecology, comparative economics, personality and culture, oceanic ethnology, Latin American ethnology, sub-Saharan African ethnology, folk and peasant society.

M.A. candidates may submit either a thesis or a term paper. If the latter is chosen, 6 credits in 500-level courses in the major field must be scheduled in lieu of thesis credits. The M.A. degree may be bypassed by exceptional candidates for the Ph.D. degree.

The communication and foreign language requirement for the Ph.D. degree includes a reading knowledge of a foreign language plus an option from among additional foreign languages, field languages, linguistics, and statistics.

Undergraduate preparation must include 12 credits in anthropology and archaeology or their equivalent and at least 6 credits in related sciences. A student with an excellent record but who does not meet these requirements may be admitted provided he makes up course deficiencies without graduate credit. Students with a 2.80 or above junior-senior average and with appropriate course backgrounds who have research interests directly related to the special anthropological competences within the department will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests.

ANTHROPOLOGY (ANTHY)

400. Human Evolution: the Material Evidence (3)
401. Human Evolution: Theory and Process (3)
402. Human Ecology (3)
403. Applied Physical Anthropology (3)
405. Primatology (3)
420. Archaeology of the Near East (3)
421. Archaeology of the Central Andes (3)
422. Archaeology of Meso-America (3)
423. Archaeology of Eastern United States (3)
424. Archaeology of Africa (3)
440. Ethnology of South America (3)
443. Ethnology of the Old World (3-6)
444. Ethnology of Meso-America (3)
446. Ethnology of North America (3)
447. Ethnology of Sub-Saharan Africa (3)
449. Ethnology of Southeast Asia (3)
450. Comparative Social Organization (3)
451. Economic Anthropology (3)

453. (Soc. 453) Primitive Religion (3)
455. Culture and Personality (3)
456. Cultural Ecology (3)
457. Language in Culture (3)
460. Anthropological Theory (3)
461. Methods in Cultural Anthropology (3)
462. Methods in Archaeology (3)
463. Field Linguistics (3)
471. History of Anthropological Theory (3)

501. Evolution of Human Behavior (3) The application of evolutionary theory to the study of man's structure, function, and culture. Prerequisite: Anthy. 21 or 401, and 3 additional credits in anthropology, sociology, or psychology.

502-503. Ecological Theory in Anthropology (3 each) Man's biology, culture history, and culture variation from the ecological perspective. Two-term enrollment required. Prerequisite: 6 credits in anthropology.

504. Applied Anthropology (3) Methods and results of studies in which anthropological theory was applied to current problems in human biology and culture.

505. Naturalistic Behavior of Nonhuman Primates (3) Comparative study of behavior including taxonomy, geographic distribution, ecology, territoriality, population composition, grouping patterns, individual and group interactional characteristics, communication.

506. Cultural Dynamics (3) Survey of the major theories of culture change with special reference to archaeological research.

507. The Biology of Human Adaptability (3) An exploration of the biological mechanisms which aid man's survival in a variety of environmental settings.

508. Research Problems in Culture History (3-9)

509. Seminar in Regional Studies (3-9) Research and analysis in selected world cultural areas, including ecology, prehistory, history, ethnography, and current status.

510. World Ethnographic Survey (3) General survey of world cultures and their historical development.

530. Individual Readings in Anthropology (1-6) Reading or research in selected aspects of general anthropology.

531. Individual Research in Anthropology (3-6)

545. Seminar in Anthropology (1-9) Critical analysis of research in selected areas of anthropology.

560. Anthropological Theory (3) Theory used in culture-historical, sociological, and psychological interpretations.

561. Field Methods in Anthropology (3-9) Individual field work in any aspect of anthropology, supervised by staff of professional rank.

562. Laboratory Methods in Anthropology (3-9) Supervised laboratory research, utilizing materials from physical anthropology or archaeology or cultural anthropology.

563. Seminar in Linguistic Anthropology (3-6) Organized research on special topics in linguistic anthropology.

ARCHITECTURAL ENGINEERING (A E)

GIFFORD H. ALBRIGHT, *Head of the Department*
101 Engineering A Building

Degree Conferred: M.S.

Graduate Faculty: Senior Members McLaughlin and Tichy.
Graduate Faculty: Associate Member Albright.

Students may specialize in structural analysis and design, environmental control engineering, illumination, acoustics, materials of construction, building construction management, computer application to building design and performance, or nuclear defensive and protective construction. The latter area includes shelter planning, effects of nuclear weapons, shelter environmental requirements, analysis and design of blast-resistant structural systems, and integrated engineering requirement for protective construction.

For admission a student must have a strong background in some field of engineering; in engineering science or mechanics; or in architecture, psychology, economics, or management if there is adequate preparation in the physical sciences and mathematics. The detailed requirements depend upon the student's area of special interest.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

ARCHITECTURAL ENGINEERING (A E)

401. ARCHITECTURAL ENGINEERING (3)
402. ARCHITECTURAL ENGINEERING (3)
403. ARCHITECTURAL ENGINEERING (3)
430. ARCHITECTURAL ENGINEERING (3)
431. ARCHITECTURAL ENGINEERING (3)
439. ARCHITECTURAL ENGINEERING (3)
441. INTEGRATION OF ARCHITECTURAL ENGINEERING SYSTEMS (3)
442. RESEARCH IN ARCHITECTURAL ENGINEERING (1-6)
454. ENVIRONMENTAL ENGINEERING IN BUILDINGS—DESIGN (3)
458. ADVANCED ARCHITECTURAL ACOUSTICS AND NOISE CONTROL (3)
464. ADVANCED ARCHITECTURAL ILLUMINATION SYSTEMS DESIGN (3)
471. BUILDING CONSTRUCTION ASSEMBLIES (3)
472. BUILDING CONSTRUCTION MANAGEMENT I (3)
473. BUILDING CONSTRUCTION MANAGEMENT II (3)
474. BUILDING COST ANALYSIS (3)
475. BUILDING CONSTRUCTION ENGINEERING I (3)
476. BUILDING CONSTRUCTION ENGINEERING II (3)
477. BUILDING PROJECT ANALYSIS (3)
481. ARCHITECTURAL ENGINEERING THESIS (2)
482. ARCHITECTURAL ENGINEERING THESIS (2)
483. ARCHITECTURAL ENGINEERING THESIS (2)
486. PROFESSIONAL ENGINEERING PRACTICE (3)

502. ARCHITECTURAL ENGINEERING (3-8) Advanced structural design in steel and reinforced concrete. Lectures and class criticism. Practicum and seminar.

503. ARCHITECTURAL ENGINEERING (4-8) Continuation of A.E. 502 in which

problems of wind bracing in tall buildings, rigid frames, and heavy-framed constructions are studied. Practicum and seminar.

542. Advanced Problems and Research in Architectural Engineering (2-12) Investigation, analysis, and preparation of comprehensive report on subject relating to special problems in architectural engineering systems.

545. Architectural Engineering Seminar (1-6) Current literature and special problems in architectural engineering; presentation of technical papers.

551. Advanced Nuclear Defense Planning and Design I (3) Weapons effects data; dynamic strength of materials and structural elements; dynamic design; architectural, structural, electrical, and mechanical requirements for shelters. Prerequisites: A.E. 4, 5; E.Mch. 12.

552. Advanced Nuclear Defense Planning and Design II (3) Blast-resistant design of framed structures, shear wall structures, arches, domes, and underground structures; radiation shielding characteristics of building materials. Prerequisites: A.E. 431, 432, 551; Phys. 237.

553. Selected Problems in Nuclear Defense Research (1-6)

ARCHITECTURE (ARCH)

Raniero Corbelletti, *Head of the Department*
308 Sackett Building

Degree Conferred: M.S.

Graduate Faculty: Senior Members Corbelletti and Golany.
Graduate Faculty: Associate Member Hallock.

Advanced studies are offered in architecture, urban design, and planning. The student is offered opportunity for independent research and extensive interdisciplinary work under the guidance of specialists and scholars in technical, cultural, industrial, and social fields.

For admission, a five-year bachelor's degree program in architecture is required.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

ARCHITECTURE (ARCH)

400. Special Projects (4-12)
408-409-410. Applied Architectural Design (5 each)
441. Architectural Design Analysis (3)
442. Architectural Design Analysis (3)
443. Architectural Design Analysis (3)
464. Architectural Systems—Comparative Analysis of Structure (1)
465. Architectural Building Materials (3)
475. Architectural Systems—Environmental Control (2)
490. Architectural Research (1-12)

515. New-Towns Planning Seminar (3) Examination of the process, concepts,

and structure of new-towns planning as a response to contemporary urban-regional development problems.

516. New-Communities Seminar (3) Examination and evaluation of the new-communities movement in the United States.

530. Architecture I (4-12) Problems in architectural planning and design. Programming and/or implementation methodologies and applications for various environmental design scales.

531. Architecture II (4-12) Continuation of Arch. 530 with concentration and specialization options.

532. Comprehensive Planning Process Studio (4-12) Field case studies in analysis forecasting and projections of urban physical design elements. Preparation of comprehensive plan, regulations, and implementation.

535. New-Towns Planning Studio (4-12) A team workshop of planning and design of new towns, involving data gathering, surveys, analysis, projection, and implementation.

591. Architectural Research (2-12) Guided research project.

ART (ART)

Robert H. Gray, *Head of the Department*
102 Visual Arts Building

Degrees Conferred: M.A., M.F.A.

Graduate Faculty: Senior Member McCoy.
Graduate Faculty: Associate Members Adams, Altman, Cook, DonTigny, Frost, Shobaken, and Zoretich.

The M.A. program is planned to provide a broad range of experience and study in the visual arts. A thesis in an area of specialization is required. Requirements for admission include a broad undergraduate training in art and the presentation of a portfolio or examples of the student's work.

The M.F.A. program is planned to provide professional emphasis in a specific area of art. A creative project and supporting monograph are required. Requirements for admission include 24 credits in studio art with some indication of concentration in a chosen area and a statement of purpose concerning the professional aims of the candidate. A portfolio, photographs, or examples of the student's work must be presented.

All students accepted for graduate study in art who lack the adequate undergraduate courses or show deficiencies in some area will be required to take additional course work without degree credit.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

ART (ART)

†411. Seminar in Contemporary Art (3)

†May be repeated for a total of 6 credits.

*412. Individual Instruction (1-6)
*425. Advanced Drawing (3)
*430. Advanced Sculpture (3)
*448. Advanced Printmaking (3)
*450. Advanced Painting (3)
*460. Advanced Watercolor (3)
470. Graphic Design II (3)
471. Graphic Design III (3)
472. Exhibition Concepts and Structure (3)
473. Seminar in Design Research (3)
*480. Advanced Ceramics (3)
*495. Advanced Photography (3)

501. Art Research (2-6) Original study and practice in art relating to material, concept, or technique.

530. Advanced Sculpture (3-12) Individual projects in sculpture leading to the development of a collection or body of work representative of the artist.

545. Printmaking (2-12) Problems in printmaking leading to the development of a collection or body of work representative of the individual artist.

550. Painting (2-12) Individual problems in painting leading to the development of a collection or body of work representative of the artist.

570. Design (2-12) Individual projects in design with special emphasis on professional practice in specialized fields of graphic design.

580. Ceramics (2-12) Experimental problems in ceramics leading to the development of a collection or body of work representative of the individual.

ART EDUCATION (A ED)

Harlan E. Hoffa, *Head of the Department*
269 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Beittel, Edmonston, Hoffa, and Stewart.
Graduate Faculty: Associate Members Bradley, Chomicky, and Schwartz.

This program prepares students for careers in public school art teaching, art supervision, college teaching, administration, or research. To be admitted without deficiencies, the student is expected to have completed either a baccalaureate program in art education or a program leading to certification. Such a program would include work in art studio, art history, art education, education, educational psychology, and psychology. Deficiencies may be made up by course work which is not counted as credit toward an advanced degree.

All students are expected to complete two years of teaching before receiving the doctor's degree. Students seeking the Ph.D. degree must satisfy one of four communication and foreign language requirements. These options include foreign languages, statistics, computer science, historiography, logic, or philosophical method.

Students with a 2.75 junior-senior average and with appropriate course backgrounds

* May be repeated for a total of 12 credits.

will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.75 grade-point average may be made for students with special backgrounds, abilities, and interests. Transcripts should indicate high attainment in appropriate academic and creative work, and recommendations should attest to scholarship and ability to work independently. Creative work, as shown by slides and photographs, should show a high level of involvement and sensitivity to aesthetic forming processes.

Students who seek admission to the graduate program must make formal application to the Admissions Committee of the Department of Art Education.

ART EDUCATION (A ED)

401. Studies in Art Media (1-10)
404. Methods of Graphics and Illustrations (3)
414. Advanced Crafts for Teachers (3-6)
420. Ceramics for Teachers (3)
434. Art Appreciation in the Educational Program (3)
435. Art in the Elementary School (3)
436. Art in the Secondary School (3)
486. Current Problems in Art Education (2-3)
487. Mural Painting in Schools (3)
488. Advanced Mural Painting in Schools (3)
489. Art Experiences with Children (3)
490. Introduction to Research in Art Education (3)

501. Seminar in Art Education (1-6) The analysis of fundamental concepts derived from related disciplines; the examination of current problems; current literature.

504. Advanced Method in Graphic Processes (3) Exploration through laboratory experience of printing method: etching, silk screen, linoleum, or other; applications in teaching.

514. Functional Relationships in Crafts (3) Relationships of material design and purpose in crafts discussed by means of outstanding products of different materials, periods, and cultures. Prerequisite: 6 credits in crafts or 3 in design and 3 in advanced crafts.

516. Analysis of Three-Dimensional Processes in Art (3) Three-dimensional processes analyzed with regard to kinetic, textural, form, and other functions.

520. Advanced Ceramic Art (3) Intensified exploration of throwing, glazing, and firing processes as related to aesthetic considerations in contemporary art forms and past cultures. Prerequisite: A.Ed. 420.

535. Administration and Supervision of Art Education Programs (3) The problems and responsibilities of the city, county, and state art supervisor; curriculum, facilities, financing, supervision, in-service training, and reporting. Prerequisites: A.Ed. 435, 436.

536. Curriculum Development in Art Education (3) Factors affecting art curriculum decisions, analysis, selection, organization, preparation of curriculum. Evaluation and sources of art curriculum improvement and innovation. Prerequisite: 6 credits of methods.

588. History of Art Education (3) Historical development of philosophies in art education in the United States and abroad.

589. Research Methods in Art Education (3-6) Orientation in research methods; findings and designs related to the study of problems in art education.

595. Research in Art Education (1-6) Independent research, under an adviser, to be terminated by a scholarly report proportionately comparable in quality to a master's thesis. Prerequisite: 15 credits in art education on the 400 and 500 levels, including A.Ed. 598.

ART HISTORY (ART H)

Helmut W. Hager, *Head of the Department*
229 Visual Arts Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Battisti, Cutler, Hager, Hyslop, Mauner, van der Meulen, and Weisman.

Graduate Faculty: Associate Member Kiang.

Graduate work is offered in the following areas: modern, Renaissance and Baroque, medieval, Byzantine, and ancient. Special research opportunities are available through the Center for the Study of Renaissance and Baroque Art.

Candidates for the M.A. are required to complete a master's thesis and to demonstrate a reading knowledge of at least one foreign language, or comprehensive knowledge of one. Candidates for the Ph.D. degree must pass a written comprehensive examination upon completion of their course work and, usually, before beginning the thesis. The communication and foreign language requirement for the Ph.D. degree may be satisfied by a reading knowledge of two foreign languages, normally German and either French or Italian. Other languages may be substituted with the approval of the adviser.

For admission a minimum of 18 credits in art history is required. Lacking these, a promising candidate may be accepted on condition that he make up the deficiency without graduate degree credit. Students with a 3.00 junior-senior average and with strong backgrounds in courses related to the major will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

ART HISTORY (ART H)

400. Studies in Art History (3-6 per term)
401. Studies in Greek Art (3)
402. The Illuminated Manuscript (3)
405. Pioneers of Modern Architecture (3-6)
410. Taste and Criticism in Art (3)
411. Art of Imperial Rome (3)
412. The Gothic Cathedral (3)
414. Studies in Italian Baroque Art (3-9)
415. The Skyscraper (3)
416. American Painting: 1876-1913 (3)
422. Studies in Medieval Sculpture (3)
423. Studies in Italian Renaissance Art (3-9)
424. Masters of Northern Baroque Art (3)
425. Movements in Nineteenth-Century Art (3)
432. Problems in Iconology (3)
435. Movement in Twentieth-Century Art (3-6)

510. Studies in Art History (3-6 per term) Original investigation in art history, to be pursued independently or concurrently with course work in particular fields.

511. Seminar in Ancient Art (3-12) Selected topics from the history of Greek and Roman art.

512. Seminar in Medieval Art (3-12) Original research into problems dealing with the art of the Middle Ages.

513. Seminar in Renaissance Art (3-12) Investigations in the area of Renaissance art, centering around major masters and monuments.

514. Seminar in Baroque Art (3-12) Investigations in the area of Baroque art centering around major masters and monuments.

515. Seminar in Modern Art (3-12) Lectures, readings, reports, and discussions in the field of modern art.

517. Seminar in Eighteenth-Century Art (3-12) Investigation into themes and problems dealing with eighteenth-century art.

522. Seminar in Byzantine Art (3-12) Specific iconographical and stylistic problems in Byzantine art and its relation to classical antiquity, the medieval West, and Islam.

525. Seminar in Modern Architecture (3-12) Investigation into the works and problems of modern architecture as they relate to the culture of our times.

555. Art History Field Seminar (3-12) Investigations based on the site study of specific art objects, with trips in successive years to different art centers.

ASTRONOMY (ASTRO)

John P. Hagen, *Head of the Department*
103 Whitmore Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Hagen, Matsushima, and Sampson.
Graduate Faculty: Associate Members Bauer, Usher, Winkler, and Zabriskie.

Opportunities are available to prepare for research or teaching. The principal research facilities of the department are in radio astronomy, but work can be done in meteors, astrophysics, and in various phases of theoretical astronomy. Modern astronomy has very close ties with mathematics, physics, and engineering. The program required of a doctoral candidate would normally include courses in at least two of these related fields, in addition to those in astronomy.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by a knowledge of computer programming, which may be substituted for one of the two foreign languages required.

A bachelor's degree in astronomy, physics, mathematics, or electrical engineering is required for admission. Opportunity to make up possible undergraduate deficiencies is provided.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

ASTRONOMY (ASTRO)

430. General Astronomy for Teachers (3)
460. Fundamentals of Celestial Mechanics (3)
470. Solar Physics (3)
490-491. Introduction to Astrophysics (3 each)
492. (E.E. 492) Space Astronomy and Introduction to Space Science (3)
495. Practical Astronomy (3)

510. Astrophysics (3) An introduction to astrophysics in which the relevant physics, spectra, gas laws, plasmas, and radiation transfer theory are discussed.

511. Astrophysics (3) Stellar atmospheres; considerable emphasis is placed on the sun and on solar-terrestrial relationships. Prerequisite: Astro. 510.

512. Astrophysics (3) Stellar interiors, stellar evolution, pulsating stars, novae and supernovae; some discussions of the interstellar medium and gaseous nebulae. Prerequisite: Astro. 510.

513. Observational Techniques in Astronomy (3) Radiation quantities in theory and as observed. Astrometry, photometry, spectroscopy, stellar classification, interferometric methods. Observational laboratory. Prerequisite: Astro. 511.

516. Nonequilibrium Radiative Transfer Theory (3) Detailed study of theory of radiative transfer when the assumption of local thermodynamic equilibrium is not made, with astrophysical applications. Prerequisite: Astro. 511 or Phys. 561.

520. Galactic Structure (3) Stellar clusters and associations, galactic dynamics, stellar populations, distance determinations, luminosity calibration, and stellar statistics.

523. Observational Theory (3) Information theory of noisy signals, statistics of nonlinear functions, theory and application of convolutions, selection effects, systematic errors, selected problems. Prerequisite: Astro. 513.

530. Theory of Stellar Atmospheres (3) Theory of photospheric structure, radiative processes, and line-formation in the outer layers of stars, and interpretation of stellar spectra. Prerequisite: Astro. 511.

534. Stellar Structure and Evolution (3) A detailed study of the theory of the interiors and evolution of stars. Prerequisite: Astro. 511 or Phys. 561.

542. Gaseous Nebulae and Interstellar Matter (3) Theory and observations of galactic nebulae and interstellar medium, and problems related to the formation of stars and galactic structure. Prerequisite: Astro. 511.

545. Astrophysical Plasma Kinetic Theory (3) Kinetic theories, fluid behavior, collective phenomena, and collisional processes of plasmas and self-gravitating systems of gas and stars. Prerequisite: Phys. 530.

560-561. General Relativity and Cosmological Models (3 each) Riemannian geometry; general relativity theory and experiments; massive bodies; and Newtonian, Einsteinian, and steady state cosmologies are studied. Prerequisite: Phys. 525.

582. Radio Astronomy (3) Radiometers and antennas; signals in noise; solar physics; quiet and active solar radiation; transfer equation and solar radiation; solar-terrestrial effects. Prerequisite: E.E. 438 or Phys. 467.

583. Radio Astronomy (3) Radio astronomical studies of the moon and planets, galactic and extragalactic sources, and the structure of galaxies using line spectra. Prerequisite: Astro. 582.

BIOCHEMISTRY (BIOCH)

JOHN H. PAZUR, *Head of the Department*
109 Frear Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Clagett, Hartzell, Mallette, McCarl, Pazur, Phillips, R. Schraer, and Shigley.

Graduate Faculty: Associate Members Aronson, Hammerstedt, Niehaus, and Winter.

Opportunities for research and graduate study are available in intermediary metabolism, cellular control mechanisms, molecular genetics, enzyme structure, nucleic acids, proteins, carbohydrates, lipids, photosynthesis, and endocrinology.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by a reading knowledge of two foreign languages.

Entering graduate students should have had at least one year's work in each of the following: general chemistry, analytical chemistry, organic chemistry, physical chemistry, and general physics. Mathematics through integral calculus is also required. Students with limited deficiencies in these subjects may be admitted but must make up such deficiencies concurrently with their graduate studies. Undergraduate courses in biology, biochemistry, and foreign languages will be helpful to the student but are not required for admission.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

BIOCHEMISTRY (BIOCH)

401. GENERAL BIOCHEMISTRY (3)
402. GENERAL BIOCHEMISTRY (3)
403. EXPERIMENTAL BIOCHEMISTRY (3)
417. BIOCHEMICAL METHODS (4)
425. INTRODUCTORY PHYSICAL BIOCHEMISTRY (4)
437. PHYSIOLOGICAL BIOCHEMISTRY (3)
438. PHYSIOLOGICAL METHODS (2)
439. INDEPENDENT STUDY (1-12)

501. ENZYMES AND BIOCATALYSIS (2) Enzyme kinetics, mechanisms of enzymic catalysis, correlation of structure and function, regulation of catalytic activity, literature reports. Prerequisite: Bioch. 402.

503. BIOCHEMICAL PROBLEMS (1-10 per term) Prosecution of an assigned problem under the guidance of an instructor.

507. SEMINAR IN BIOCHEMISTRY (1 per term)

510. PROTEINS (2) Biochemical and physical properties of proteins and polypeptides, isolation and purification techniques, sequence analysis, conformational structure. Prerequisite: Bioch. 402.

511. CARBOHYDRATES (2) Stereochemistry, conformational analysis, and chemical reactivity of carbohydrates; biochemistry of monomeric and macromolecular carbohydrates. Prerequisite: Bioch. 402.

512. LIPIDS (2) The structure, biosynthesis and metabolism of fatty acids, glycerides, phospholipids and sterols. Prerequisite: Bioch. 402.

515. The Biosynthesis of Macromolecules (2) An enzymological approach to the biosynthesis of DNA, RNA, proteins, complex polysaccharides and membranes. Prerequisite: Bioch. 402.

519. Topics in Metabolism (2) Selected topics dealing with metabolism and metabolic control, literature reports; may be repeated once in successive years. Prerequisite: Bioch. 402.

521. Biochemical Methods (3) Lectures and advanced laboratory on current techniques pertaining particularly to research on lipids and carbohydrates. Prerequisite or concurrent: Bioch. 511, 512.

530. Contemporary Topics in Biochemistry and Molecular Biology (2-4) Lectures and discussions by visiting lecturers on new and significant developments in biochemistry and molecular biology.

BIOLOGICAL CHEMISTRY (BCHEM)

Louis F. Hass
In Charge of Graduate Programs in Biological Chemistry
The Milton S. Hershey Medical Center

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Davidson, Hass, and Rosenberg.

Graduate Faculty: Associate Members Hill, Miljkovic, Murray, Roark, and Shiman.

Opportunities for research and graduate study are available in the chemistry and metabolism of complex polysaccharides, cellular differentiation, mechanism of enzymatic reactions, biochemical genetics, biochemistry of complex lipids, conformational analysis of carbohydrates and proteins, natural product chemistry, and physical chemistry of macromolecules.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. Interested students should contact the Director of Graduate Programs.

Research and graduate study opportunities are also available in the Department of Biochemistry at University Park.

BIOLOGICAL CHEMISTRY (BCHEM)

502. Biological Chemistry (5) Principles of biological chemistry with emphasis on the relationship of macromolecular structure to function in metabolic pathways and specialized tissues.

503. Biological Chemistry of Nucleic Acids (2) Detailed discussion of nucleic acid biochemistry and its relation to genetic phenomena, especially organization, mutation, and segregation of genetic material.

513. Biological Chemistry Macromolecules (3) Methods of detailed determination of the three-dimensional structure of macromolecules, primarily enzymes and amino acid sequence and conformation of protein.

523. Metabolism (3) Molecular mechanisms employed by living systems to transform biological compounds, control production and utilization of energy, and regulate metabolic pathways.

540. Seminar (1 per term) Critical discussion of current literature within a facet of biochemistry; experimental design, procedures, and interpretation of results to be emphasized.

551. Kinetics and Mechanism of Enzyme Action (3) Current kinetic theory, rapid reactions, regulatory enzymes, chemical and physical approaches to the study of the mechanism of enzyme action. Prerequisite: B.Chem. 502. Concurrent: B.Chem. 523.

553. Biochemical Techniques (3) Lectures and discussion on approaches to macromolecule separation and characterization, isolation of subcellular organelles and specialized procedures for tissue fractionation. Prerequisite: B.Chem. 502.

570. Special Topics (2) Discrete areas of contemporary research in conformational analysis and natural product structure, complex polysaccharide structure, neurochemistry, and biochemistry of disease.

590. Research Problems (1-12) Individualized research on biochemical problems conducted by students in departmental laboratories.

BIOLOGICAL SCIENCE (BI SC)

Anton J. Kovar, *Chairman of the Committee on Biological Science*
121 Buckhout Laboratory

Degrees Conferred: D.Ed., M.Ed.

Graduate Faculty: Senior Members Anthony, Bellis, Butler, Cheng, Cooper, Dalton, Fergus, Grun, Hale, Hamilton, Hillson, Hymer, Kovar, Pursell, Spackman, Therrien, Traverse, Wagner, Wickersham, Witham, and Wright.

Graduate Faculty: Associate Members Adams, Costantino, Hollis, Keener, Mitchell, Neff, and Wood.

The M.Ed. program in biological science is designed primarily to meet the needs of secondary school science teachers. The academic degrees M.S. and Ph.D. are not offered in biological science but are available in biochemistry, biology, biophysics, botany, entomology, genetics, microbiology, physiology, plant pathology, and zoology.

The candidate for the M.Ed. degree must earn at least 21 credits in the natural sciences with a minimum of 15 credits in the biological sciences, including at least 6 in the animal sciences and 6 in the plant sciences. In addition, at least 6 credits in education and a term paper are required. It is suggested that the candidate have at least 2 years of teaching experience before applying to this program.

The D.Ed. program is designed for secondary school and college science teachers. Major course requirements are designated by the candidate's committee with the concept that teachers of biology have a broad background in biological disciplines and related fields. A minimum of 15 credits each is required in professional education and in thesis research. The requirement of a foreign language is at the discretion of the candidate's committee.

In order to enter a program for a higher degree with a major in biological science, the candidate should present 30 credits in the natural sciences, including one year of organic chemistry and one year of physics. A limited number of undergraduate deficiencies may be made up in pursuit of the advanced degree. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

BIOLOGY (BIOL)

JOSEPH G. O'MARA, *Head of the Department*
208 Life Sciences I Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Anthony, Bellis, Butler, Cheng, Cooper, Dalton, Dunson, Fergus, Gaffney, Grove, Grun, Hale, Hamilton, Hibbard, Hillson, Hymer, Kneebone, Kovar, O'Mara, Pursell, Schein, Spackman, Therrien, Traverse, Wagner, Wickersham, Williams, Witham, and Wright.

Graduate Faculty: Associate Members Abplanalp, Adams, Costantino, Hollis, Keener, Mitchell, Neff, and Wood.

The department will direct graduate programs in behavior, cell biology, cytology, cytochemistry, environmental science, ultrastructure, and other aspects of modern biology. The courses of study are planned individually by the student and an adviser. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language. Candidates have an option of a thesis or a paper for the M.S. degree.

Admission is restricted to students who have the baccalaureate degree in a biological science and who present a 2.80 junior-senior average. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the requirements for admission can be made for students with degrees in related subjects who will remedy their undergraduate deficiencies concurrently with their graduate studies.

BIOLOGY (BIOL)

402. VERTEBRATE NEUROANATOMY (3)
403. (Ent.) SYSTEMATICS (3)
404. PRACTICUM IN EXPERIMENTAL NEUROANATOMY (1-4)
405. GENERAL CYTOLOGY (3)
*406. SEMINAR IN NEUROANATOMY (1-6)
407. PLANT ANATOMY (3)
410. GENERAL LIMNOLOGY (3)
411. PLANT BIOLOGY FOR TEACHERS (3)
412. PLANT BIOLOGY FOR TEACHERS (3)
414. ADVANCED SYSTEMATIC BOTANY (3)
415. THE LITERATURE OF ZOOLOGY (1)
416. THE METHODS OF RESEARCH IN ZOOLOGY (2)
417. INVERTEBRATE ZOOLOGY (3)
418. MYCOLOGY (3)
419. GENERAL ECOLOGY (3)
420. (Geol. 420) PALEOBOTANY (3)
421. COMPARATIVE ANATOMY OF VERTEBRATES (4)
422. ADVANCED GENETICS (3)
423. (Geol. 423) INTRODUCTORY PALYNOLOGY (3)
424. BOTANICAL TECHNIQUE (3)
425. GENETICS OF FUNGI (3)
426. INTRODUCTORY CYTOGENETICS (3)
427. EVOLUTION (3)
428. THE GENETICAL THEORY OF NATURAL SELECTION (3)

*May be repeated for up to 6 credits.

430. (Bphys. 430) Molecular Biology of the Gene (3)
431. Comparative Plant Morphology (2)
432. Laboratory in Comparative Plant Morphology (2)
437. Histology (4)
440. Embryology (4)
441. Plant Physiology (3)
442. Plant Physiology (3)
443. Plant Physiology (3)
444. Biological Problems (1-6)
445. Plant Growth Substances (3)
448. Ornithology (3)
450. Plant Autecology (3)
451. Plant Synecology (3)
452. Ichthyology (3)
461. Animal Parasitology (3)
462. (Pty.Sc. 462) Animal Behavior—Ethology (3)
463. (Pty.Sc. 463, Psy. 463) Animal Behavior Laboratory (1-2)
470. Comparative Environmental Physiology (4)
472. Vertebrate Physiology (3)
473. Laboratory in Vertebrate Physiology (2)
475. Cellular Physiology (4)
479. General Endocrinology (3)
480. Marine Biology (4)
481. Aquatic Botany (3)
496. Current Topics in Biology (1-6)

500. Plant Physiology Seminar (1 per term) Selected topics from recent literature; staff and student reports on current research. Spring term, even years.

502. The Physiology of the Fungi (3) Chemical composition, metabolism, toxic and stimulating agencies, spore germination, growth and irritability of the fungi. Fall term, even years.

506. Comparative Anatomy of Vascular Plants (3) Structure of the Tracheophyta from a phylogenetic standpoint. Prerequisite: Biol. 407. Spring term, even years.

511. Advanced Plant Physiology (3) Physiology of plants including uptake of water and minerals, translocations, mineral nutrition, energy relations, respiration and catabolism. Prerequisite: Biol. 442. Fall term.

512. Advanced Plant Physiology (3) Continuation of Biol. 511. Physiology of plants including photosynthesis, synthesis of cellular constituents, growth and development. Prerequisite: Biol. 442. Winter term.

513. Biology Seminar (1 per term) Presentation and discussion of selected topics.

516. Ecological Plant Geography (3) Distribution of plant communities; environmental factors which influence their present distribution; geological-historical development of plant communities, their past distribution. Winter term, odd years.

518. Special Problems (1-6) Prosecution of an assigned problem under the guidance of a staff member. Throughout the year as arranged. By appointment.

519. Zoogeography (3) The present distribution of world vertebrates, their evolution, and their patterns of dispersal in the past.

521. Medical and Industrial Mycology (3) Structure, life histories, classification, and techniques of study of the fungi pathogenic to man and of fungi important in industry. Fall term, odd years.

522. Myxomycetes, Phycomycetes, and Ascomycetes (4) Morphology, taxonomy, phylogeny, and life histories; identification and field work. Prerequisite: Biol. 418. Winter term, even years.

523. Basidiomycetes and Fungi Imperfecti (4) Morphology, taxonomy, phylogeny, and life histories. Prerequisite: Biol. 418. Spring term, even years.

524. Seminar in Genetics (1 per term)

526. (Geol. 526) Problems in Palynology (1-6) Systematics; paleoecological palynology; Paleozoic palynology; Mesozoic and Cenozoic palynology; Pleistocene vegetational history.

528. Biometrical Genetics (3) Hereditary structure of populations fusing the principles of genetics, mathematics and statistics, genetic analysis of quantitative traits, artificial selection theory. Prerequisite: Biol. 428 and Stat. 402 or Agro. 545.

531. Bryology (3) Morphology, taxonomy, and ecology of liverworts, hornworts, and mosses; collection, preservation, culturing, and cytologic techniques. Spring term, even years.

533. Problems in Genetics (2-6) Problems to suit needs of individual students; conferences and laboratory work.

535. Morphology of the Tracheophyta Exclusive of Angiosperms (3) Origin, developmental tendencies, structure, and paleobotanical evidence. Winter term, odd years.

536. Morphology of Angiosperms (3) Floral origin and development, fertilization, embryogeny, seeds and fruit development. Prerequisite: Biol. 431.

537. (Sec.Ed. 537) Workshop in the Biological Sciences (3) Projects designed for teachers of biology in the secondary schools. Summer term only.

538. Principles of Microscopic Histochemistry (2) Theoretical basis for the microscopic identification, localization, and quantitative analysis of chemical substances in tissues of organisms. Prerequisite: Biol. 405 or 437.

539. Analytical Histochemistry Laboratory (2-4) Application of histochemical techniques in the microscopic analysis of tissue lipids, proteins, carbohydrates, nucleic acids and proteins. Prerequisite or concurrent: Biol. 538.

540. Phycology (4) Comparative morphology, taxonomy, and ecology of fresh water and marine algae; culturing, collection, preservation techniques. Prerequisite: Biol. 424.

541. Comparative Physiology (3) Phylogenetic variation in the regulation of the internal environment of animals.

546. Principles of Animal Populations (3) Ecological laws governing population growth and decline; reproductive and mortality rates; predation and composition as limiting factors. Fall term.

550. Neurogenesis (2) Embryonic and evolutionary development of the nervous system. Determination, differentiation, orientation, and specificity of growing and regenerating nerve cells. Prerequisite: Biol. 440.

571. (Phsio. 571) Animal Physiology (2) Physiology of fluid transport mechanisms; examination of the distribution and regulation of body fluids, blood, and hemodynamics. Prerequisite: 3 credits in physiology.

572. (Phsio. 572) Animal Physiology (2) Examination of nutrition, metabolism, and respiration as they relate to subcellular, cellular, and organ organizational levels of the whole animal. Prerequisite: 3 credits in physiology.

573. (Phsio. 573) Animal Physiology (2) Detailed examination of animal reproduction, endocrine secretion and control, neural muscular activity, central nervous system correlates, and special senses. Prerequisite: 3 credits in physiology.

574. (Phsio. 574) Animal Physiology Laboratory (1-6) Selected problems using advanced physiological techniques to study transport mechanisms, circulation, excretion, respiration, metabolism, and neuroendocrines. Prerequisite: Biol. 473.

581. Advanced Invertebrate Zoology (3) Morphology, physiology, taxonomy, and life histories of invertebrate animals.

582. (Pty.Sc. 582, Psy. 582) Research in Animal Behavior (2-6 per term) Research in special areas of animal behavior involving field or laboratory work.

583. Experimental Endocrinology (4) Problems in endocrinology designed to demonstrate the role of hormones in the regulation of physiological phenomena.

BIOPHYSICS (BPHYS)

William D. Taylor, *Head of the Department*
618 Life Sciences Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Deering, Ginoza, Morgan, Person, Rake, Scheie, H. Schraer, Smyth, Snipes, Strother, and Todd.

This program is designed for those interested in applying physical methods to the problems of living systems. Courses are offered in molecular biophysics (an introductory course), nucleic acids, radiation action, cellular physiology, biophysical instrumentation, general biophysics, physics of viruses, and physics of the cell. Advice on the selection of other courses to meet the needs of each student is provided by the faculty. These include courses in physics, chemistry, biochemistry, zoology. botany, and microbiology. The communication and foreign language requirement for the Ph.D. degree may be satisfied by one foreign language and proficiency in English.

A student with a degree in physics, biology, chemistry, or engineering is eligible for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Opportunity to make up possible undergraduate deficiencies is provided in the program.

BIOPHYSICS (BPHYS)

410. Special Topics (1-6)
430. (Biol. 430) Molecular Biology of the Gene (3)
473. Introductory Biophysics (3)
474. Molecular Biophysics I (3)
475. Molecular Biophysics II (3)

501. Seminar in Cell Biology (1) Discussion of current problems and ideas in cell biology with emphasis on reference to recent literature.

579. Photobiology (2) Effects of visible and ultraviolet light on biological systems: energy absorption, transfer, utilization; photochemistry; metabolic and genetic responses; repair systems.

580. Biophysical Science (3) Enzyme kinetics; thermodynamics of biological systems; molecular theory of reaction rates; structural aspects of biological reactions. Prerequisite: Bphys. 474 or Chem. 451.

581. Radiation Biophysics (2) The action of ionizing radiation and of radioactive decay on biological systems: molecular and cellular aspects. Prerequisite: Bphys. 475.

582. Biophysics of Nucleic Acids (3) Biophysical studies on the structure and function of the nucleic acids, particularly those of bacterial and viral origin.

585. Biological Ultrastructure (4) The application of electron microscopy to the study of cell biology. Prerequisite: any of the following—Bphys. 473; Biol. 405, 437; Micrb. 401.

586. Biological Macromolecules (3) Biopolymer characteristics; polymer statistics; size and shape determination; methods of separation; polyelectrolytes; optical and mechanical properties; denaturation; degradation; biosynthesis. Prerequisite: Bphys. 475 or Chem. 451.

587. Ultracentrifugation (2) A laboratory course in ultracentrifugation techniques including applications to biophysical problems. Prerequisite: Bphys. 474.

588. Physiology of Nerves, Muscles, and Sense Organs (2-6) Current literature on the function of nerves, muscles, and receptors. These subjects are considered individually in successive years. Prerequisite: a 400-level course in physiology, biophysics, or physiological psychology.

589. Mammalian Cell Culture (3) Recent research in quantitative cell biology as studied with tissues and cells of higher organisms cultured *in vitro*. Prerequisite: Bioch. 401.

591. Microspectrophotometry (2) Principles of absorption spectroscopy; microspectrophotometer design; determination of cellular constituents using stained and unstained preparations; laboratory exercises. Prerequisite: graduate student standing.

595. Electron Spin Resonance Spectroscopy (3) Experimental and theoretical aspects of electron spin resonance spectroscopy to provide ability for its application to biophysical problems. Prerequisite: basic knowledge of quantum mechanics and electromagnetic waves.

BOTANY (BOT)

Joseph G. O'Mara, *Head of the Department of Biology*
208 Life Sciences I Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Fergus, Grove, Grun, Hamilton, Hillson, Kneebone, Kovar, O'Mara, Pursell, Schein, Spackman, Therrien, Traverse, Wagner, Witham, and Wright.

Graduate Faculty: Associate Members Adams, Costantino, and Keener.

Botanical programs are offered in plant anatomy, cytology, ecology, genetics, morphology, mycology, physiology, and taxonomy. A student having a degree in science or in one of the biological sciences is eligible for admission. Entering graduate students should have had basic courses in chemistry, mathematics, and physics. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests.

See also Genetics and Physiology.

NOTE: *For courses in Botany and related subjects see Biology.*

BUSINESS ADMINISTRATION (B A)

MAX D. RICHARDS
In Charge of Graduate Programs in Business Administration
102A Boucke Building

Degrees Conferred: Ph.D., M.S., M.B.A.

Graduate Faculty: Senior Members Babione, Beik, Bennett, Bither, Bradley, Carroll, Clewett, Cook, Coyle, Cramer, Ferrara, Fishburn, Greenlaw, Hammond, Heitmann, Hottenstein, Kelley, Koot, Malcom, Mathews, McKinley, Pashek, Philippatos, Philips, Richards, Rigby, Schrader, Shilling, Slocum, Spychalski, and Waters.

Graduate Faculty: Associate Members Aggarwal, Bear, Carpenter, Curley, Daniels, Dolich, Francia, Hayya, Hellriegel, Hrebiniak, Kochenberger, Koehler, Melander, Millman, Nelson, Pfaffenberger, Phalan, Susman, Walker, Williams, Wilson, and Wyman.

The M.B.A. is a professional program for education in business administration to prepare individuals for administrative positions in business, institutional, and governmental management. Both applicants whose undergraduate preparation has been in business and those in fields other than business are encouraged to apply.

Preparatory courses in accounting, business law or the legal environment, business statistics, calculus, financial management, macroeconomics, microeconomics, management, and marketing are required. The M.B.A. program itself requires 36 credits of graduate courses and a professional paper.

The M.S. and Ph.D. programs with a major in business administration are designed for those interested primarily in research and teaching. The communication and foreign language requirement for the Ph.D. degree may be satisfied by a reading knowledge of two foreign languages or a reading, listening, and speaking knowledge of one language. The candidate may substitute quantitative analysis and/or behavioral science for the required reading knowledge in one or two languages.

For admission to the M.S. program, approximately 30 acceptable undergraduate credits in business administration, economics, and mathematics are required. An applicant may be admitted with deficiencies to be made up without degree credit. A student has an option of a thesis or a paper for the M.S. degree.

Applicants are evaluated for admission on the basis of academic potential and other factors giving evidence of a high probability of completing the program. Data useful for evaluating academic potential include the applicant's experience, junior-senior average, ATGSB test scores, and academic recommendations. The best qualified applicants will be accepted up to the number of spaces that are available for new students.

Applicants to any of the graduate programs in business administration are required to take the Admission Test for Graduate Study in Business (ATGSB) given by the Educational Testing Service and used by leading graduate business schools throughout the country to supplement other criteria for admission. Candidates are strongly urged to take the test at the earliest possible date. It is given at University Park and at numerous locations in most states and foreign countries in November, February, April, June, and August. For dates and locations, see the *Bulletin of Information,* Admission Test for Graduate Study in Business, Educational Testing Service, Princeton, N. J. Applicants should read the bulletin carefully. All arrangements for taking the test are made directly with the Educational Testing Service.

This graduate program is accredited by the American Association of Collegiate Schools of Business.

ACCOUNTING (ACCTG)

401. Advanced Accounting (3)
403. Auditing (3)
404. Managerial Accounting (3)
406. Advanced Federal Tax Accounting (3)
409. Machine and Electronic Accounting Methods (3)

*398G. Accelerated Elementary Accounting (3) The theory and technique of financial and managerial accounting: preparation, analysis, and interpretation of financial statements. Open to graduate students only.

503. Seminar in Auditing (3) The attest function of independent public accountants, verification of financial statements; problems of evidence, independence, ethics, professional responsibilities. Prerequisite: Acctg. 403.

504. Seminar in Managerial Accounting (3-6) Accounting and the managerial processes of planning, control, and decision making.

507. Seminar in Financial Accounting (3) Theoretical basis of financial accounting.

508. Contemporary Issues in Accounting (3) Selected problems of current interest to the accounting profession.

511. Financial and Managerial Accounting (3) Fundamental financial and managerial accounting concepts and issues from the viewpoint of the report user.

512. Financial Accounting Theory and Reporting Problems (3) Measurement and reporting of financial information for external purposes, with particular attention to current problems in asset and income measurement. Prerequisite: Acctg. 511.

515. Development of Accounting Thought (3) Development of accounting thought from ancient civilizations to the present.

BUSINESS ADMINISTRATION (B A)

503. Seminar in Public Utilities (3)

537. (Cmp.Sc. 537) Management Information Systems Design (3) Cost, value, and technical considerations in analysis and design of information systems whose purposes are to aid decision making in organizations.

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* No graduate credit is given for this course.

538. Information Systems for Planning and Control (3) Analysis of information requirements for planning, decision making and performance measurement in organizations.

539. Seminar in Management Information Systems (3) Special topics selected from contemporary issues in management information systems.

540. Business Administration Theory and Practice (3) An integrating course primarily for M.S. students using cases requiring analysis involving interrelated aspects of business administration and control.

541. Readings in Business Administration (6) Critical study and discussion of important topics in business administration.

550. Behavioral Science in Business (3) Application of behavioral science concepts and analytical methods to problems in business organizations. Analysis of administrative behavior and decision making.

552. Business Research Methods (3) Research methods applicable to business problems with emphasis on means of obtaining data and the logic underlying research design.

555. Business and Society (3) Evolution of the business organization and the changing framework of its operations, responsibilities, and social control.

574. Business Research (1-3) A project paper, comparable in quality and scope of work to a graduate thesis, on problems of a company. Prerequisite: 15 credits of 400 and 500 courses in business administration.

577. Administrative Integration (3) An analysis of coordination of the functional areas of business in relation to overall company objectives. Prerequisite: 15 credits of 400 and 500 courses in business administration.

BUSINESS LAW (B LAW)

*398G. Accelerated Business Law (3) Social control through law: courts; policies underlying individual rights; negotiable and nonnegotiable contractual rights in society. Open to graduate students only.

BUSINESS LOGISTICS (B LOG)

412. Transport Planning Analysis (3)
420. Urban Transportation (3)
430. Transport Problems (3)
440. Logistics Systems Analysis (3)

538. Logistics Systems Management (3) Control of the movement of goods; coordination of supply and demand in creation and maximization of time and place utility.

540. Transport Policy (3) Role of transport in the economy. Transport systems elements, development, cost and pricing characteristics. Public control and public policies.

541. Socioeconomic Analysis in Transportation (3) Role of transport in social and economic activity. Planning and coordination of transport systems. Designed for the Traffic Engineering program.

* No graduate credit is given for this course.

565. Seminar in Business Logistics (3-6)

FINANCE (FIN)

406. Security Analysis and Portfolio Management (3)
408. Financial Markets (3)
410. Speculative Markets (3)

*398G. Accelerated Financial Management (3) Financial planning and forecasting; management of working capital, capital budgeting, and dividend policy; capital structure and valuation. Open to graduate students only.

504. Problems in Finance (3-6) Planned individual projects involving library, laboratory, or field work.

506. Portfolio Theory and Policy (3) Rigorous examination and analysis of asset-holder behavior under conditions of risk and uncertainty.

508. Analysis of Financial Markets (3) Analysis of factors affecting price determination in financial markets.

510. Contemporary Issues in Financial Institutions (3) Critical investigation of problems of current interest in the market structure and internal operations of financial institutions.

531. Financial Management (3) An intensive examination of techniques available to aid the financial manager in decision making.

532. Normative Models in Business Finance (3) Application of advanced analytical techniques and models to financial decision making under uncertainty.

541. Financial Theory (3) A theoretical analysis of the elements of finance.

561. Seminar in Finance (3-6) Comparative analysis of research in the theories of finance; relationships to business management practices.

INSURANCE (INS)

400. Estate Planning (3)

500. Insurance Theory and Practice (3) Insurance as an institution, a technique, a legal contract; its environment as a regulated industry.

504. Problems in Insurance (3) Planned individual projects involving library, laboratory, or field work.

510. Risk Management (3) Analysis of managerial problems and responsibility for risk analysis, removal or reduction, and allocation of corporate resources to provide indemnity.

520. Seminar in Insurance (3-6) Selected topics on advanced aspects of risk management with emphasis on the insurance technique for treating hazards.

INTERNATIONAL BUSINESS (I B)

501. The International Environment (3) Conceptual approach analyzing and predicting influences of social, political, and economic norms and values upon diverse societies' managerial decision making.

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* No graduate credit is given for this course.

502. International Business Macro Theory and Policy I (3) International economic trade and monetary tools are applied to current national policy issues to determine effects on international business operations. Prerequisite: Econ. 333.

503. International Business Micro Theory and Policy I (3) Analysis of the internal operations of multinational firms; design of optimal strategies of operation under varying environmental conditions.

504. Seminar in International Business (3-6) Seminar techniques applied to selected topics; market structures; capital budgeting, investment; comparisons of foreign norms and values; multinational organization characteristics.

MANAGEMENT (MGMT)

410. Operations Planning and Control (3)
420. Management of Personnel Systems (3)
422. Advanced Organization Theory (3)
430. Administrative Management (3)
432. Simulation of Management Systems (3)
435. Cases in Public Relations (3)

*398G. Accelerated Business Management (3) The concepts of management and its decision processes including special attention to operations management.

510. Operations Management (3) Integration and application of decision making to operational and policy problems within the business firm.

515. Design of Operation Output Systems (3) Examination of research-based findings in operations management with a focus on the design and reliability of production systems.

516. Operations Planning and Control (3) Examination of research-based findings in operations management. The focus is on the operation and control of production systems.

517. Conceptual Bases of Sociotechnical Systems (3) Integrates behavioral science and operations management in sociotechnical framework. Design of sociotechnical systems.

520. Organization Theory (3) Theoretical and operating structures in formal business organizations; relation of formal organization to informal groups and to individuals.

521. Seminar in Organizational Behavior (3) Examination of research-based findings on organizational behavior. Methodological techniques for studying human behavior in formal organizations.

523. Organizational Change: Theory and Practice (3) Analysis of research, theory and practice in dynamics of organizational change. Research literature reviewed for evaluation of concepts and methods.

524. Interpersonal Relations in Organizations (3) Development of skills and sensitivity for dealing with interpersonal relationships in complex organizations. Prerequisite: B.A. 550.

531. Management Information Systems (3) Information system theories and methods applied to administrative structures and management decisions in organizations.

* No graduate credit is given for this course.

540. Personnel Management (3) Theoretical constructs underlying personnel administration; analysis of professional personnel functions in business firms.

570. Seminar in Management (3-6) Comparative analysis of research in the theories of the administrative sciences; relationships to business management practices.

MARKETING (MKTG)

424. Marketing Research (3)
435. Marketing and Public Policy (3)

*398G. Accelerated Marketing Management (3) Analyses of customer and market behavior, marketing systems, and competitive strategies; programming product, pricing, distribution, and promotion. Open to graduate students only.

500. Marketing Management (3) Analysis of management's marketing problems including market analyses, pricing, channel of distribution, promotion, competition, product strategies, and marketing research.

510. Planning Market Strategy and Programs (3) Development of marketing strategy for the firm and design of integrated product-service, promotion, and distribution programs utilizing systems analysis.

520. Quantitative Analysis for Marketing Decisions (3) Sales forecasting, new product proposals, media selection, and market testing analyzed using statistical and decision theory and other mathematical techniques.

530. Consumer and Market Behavior (3) Buying behavior: concepts from the behavioral sciences, including utility, culture, life cycle, personality, attitudes, and learning.

540. Marketing and Society (3) Marketing problems of society; domestic and regional marketing systems; governmental policies toward marketing; social performance of marketing.

544. Marketing Theory (3) The development of marketing concepts, behavioral and other marketing theories; public policy and the role of marketing in societies.

QUANTITATIVE BUSINESS ANALYSIS (Q B A)

403. Intermediate Business Statistics (3)
404. Sampling in Business Operations and Research (3)
451. Analytical Methods in Business (3)
452. Analytical Methods in Business (3)
461. Probabilistic Models in Business (3)
490. Special Topics (3-6)

*398G. Accelerated Business Statistics (3) Basic characteristics of univariate and bivariate distributions, probability theory, introduction to estimation, tests of hypotheses, and time series analysis. Open to graduate students only.

500. Seminar in Business Statistics (3-6)

501. Advanced Business Statistics (3)

510. Statistics in Business Research (3) Statistical principles and procedures essential to the interpretation and performance of research in business administration. Prerequisite: common requirements of M.B.A. program.

* No graduate credit is given for this course.

521. Quantitative Analysis for Business Decisions (3) Construction and use of quantitative models in business decision making. Prerequisite: common requirements of M.B.A. program.

527. Statistical Decision Theory (3) A systematic survey and analysis of the concepts and methods of Bayesian statistical decision theory.

532. Management Systems Simulation (3) Application of computer simulation to the analysis and design of management decision systems. Design of simulation experiments in business research. Prerequisite: 3 credits of computer programming.

550. Seminar in Mathematical Programming (3-6) Intensive treatment of theory and computational algorithms of mathematical programming; emphasis on operational application to complex management and business problems. Prerequisite: I.E. 510.

561. Stochastic Models for Management Decisions (3) Introduction to stochastic processes in business organizations. Application of stochastic models to the conceptualization, analysis, and solution of management problems. Prerequisite: Math. (Stat.) 427.

570. Management Science: Implementation and Control (3) Development and application of management science models. Model formulation and specification, sensitivity analysis, problems encountered in implementation and control.

REAL ESTATE (R EST)

400. Urban Land Utilization (3)

CERAMIC SCIENCE (CERSC)

Guy E. Rindone
In Charge of Graduate Programs in Ceramic Science
201 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Bradt, Hummel, McKinstry, Newnham, Rindone, Stubican, and Williamson.
Graduate Faculty: Associate Member Biggers.

This program is one of the options in which a graduate student in the Department of Material Sciences can receive an advanced degree. In view of the wide field covered by ceramic science, the graduate courses may be selected with a bias toward physical ceramics, chemical ceramics, or glass science.

The communication and foreign language requirement may be satisfied by (1) examinations in two languages—French examination administered by the ceramic science faculty and a second language examination by the appropriate language department or (2) examination in one foreign language *and* either 6 credits of computer science or 6 credits of statistics, or 3 credits of computer science and 3 credits of statistics.

Special facilities exist for research in the areas of electroceramics, rheology, phase equilibria, solid state synthesis, mechanical properties, ferrite and ferroelectric studies,

glass science, and high temperature reaction kinetics. Suitable preparation for graduate study in this program may be found in one of the materials sciences such as ceramics or metallurgy, in engineering fields such as chemical or mechanical engineering, in the basic physical sciences, or in the earth sciences.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

CERAMIC SCIENCE (CERSC)

400. (Min. 400) Nonmetallic Crystal Chemistry (2-3) *Mr. Newnham*
402. Principles of Ceramic Engineering (3) *Mr. Williamson*
404. Ceramic Seminar (1) *Mr. Hummel*
405. Ceramic Research and Design (1)
406. Rheology and Fluid Properties of Ceramic Systems (2) *Mr. Williamson*
407. Ceramic Materials Laboratory (2) *Mr. Williamson*
408. Heat Treatment of Ceramic Materials (1) *Messrs. McKinstry and Tressler*
409. Heat Treatment Laboratory (2) *Messrs. McKinstry and Tressler*
410. Phase Relations in Ceramic Systems (3) *Mr. Hummel*
411. Principles of Ceramic Processes (2) *Mr. Stubican*
414. Mechanical Properties of Ceramics (3) *Mr. Bradt*
415. Principles of Glass Technology (3-4) *Mr. Rindone*
420. Refractories (2-3) *Mr. Stubican*
425. Ceramic Research and Design (2)
430. Electroceramics (2) *Mr. Biggers*
431. Electroceramics Laboratory (1) *Mr. Biggers*

500. Seminar in Ceramic Science (1-2 per term) Current developments in ceramic science and related fields. Required of all graduate students in ceramic science. *Mr. Hummel and Staff*

501. Surface Behavior of Ceramic Materials (2-4) Surface chemistry of ceramics. Rheology of ceramic powders, suspensions and pastes. *Mr. Williamson*

503. Use of Phase Equilibria Data in Ceramic Science (2-5) Phase equilibria in unary, binary, ternary, and other systems; applications in product development and in understanding behavior of ceramic materials. *Mr. Hummel*

504. Solid State Reactions in Ceramic Systems (2) Thermodynamic, kinetic, and structural study of reactions and of equilibrium in ceramic systems. Prerequisites: Chem. 451, 452. *Mr. Stubican*

505. Phase Transition in Solids (2) Phase transitions will be studied in detail with respect to the crystal structure, free energy, and physical properties. *Mr. McKinstry*

506. Mechanical Properties of Ceramics (3) Theoretical consideration of internal stresses, dislocations and dislocation processes, and macro- and microstructural variables on the mechanical properties of ceramics. Prerequisite: Cer.Sc. 414. *Mr. Bradt*

507. Thermal Properties of Ceramic Materials (2-3) Heat capacity, heat of fusion, thermal conductivity, and thermal expansion in relation to macroscopic measurements and basic atomic concepts applied to ceramic materials. *Mr. Stubican*

508. Dielectric and Magnetic Properties of Ceramic Materials (2-3) Preparation and properties of ceramic semiconductors, dielectrics, and magnetic materials. *Mr. Newnham*

509. Composite Materials (3) Manufacturing processes, atomic and molecular background, and topological relationships of macro- and microstructure to the physical properties of composites. *Mr. Bradt*

510. Seminar in Glass Technology (1-2 per term) Current developments in glass technology and related fields. *Mr. Rindone*

511. The Constitution of Glass (2-3 per term) Historical and current concepts of the atomic structure of glass; relationship of structure to chemical and physical properties. *Mr. Rindone*

512. Selected Properties of the Vitreous State (2-3 per term) Measurement and interpretation of such properties as: radiation effects; viscoelasticity; electrical, mechanical, optical, and thermal properties. *Mr. Rindone*

515. Special Problems in Ceramic Science (1-6 per term) Advanced individual study on a problem in ceramics.

516. Selected Topics in Ceramic Science (1-3 per term) Intensive group study of special topics.

530. (Min. 530) Structure, Properties, and Occurrence of Clay Minerals (2-5) Structure analysis and identification of clay minerals; mineral transformation and behavior; occurrence, genesis, and petrography of fine-grained sediments. *Messrs. Brindley and Hsu*

Note: *Courses in the use of X-ray diffraction, electron microscopy, and the electron microprobe in ceramic science studies are listed under Materials Science.*

CHEMICAL ENGINEERING (CH E)

Lee C. Eagleton, *Head of the Department*
160 Chemical Engineering Building II

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Braun, Daubert, Eagleton, Engel, Jones, Kabel, Klaus, and McCormick.

Graduate Faculty: Associate Members Barton, Danner, Duda, Notter, and Ultman.

Course offerings or research facilities are available in the following areas: phase equilibria, thermodynamics, kinetics, mass transfer, transport phenomena, unit operations, unit processes, bioengineering, applied chemistry and petrochemistry, petroleum technology, rheology, and lubrication.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages or by comprehensive knowledge of one.

To be admitted, a student should be a graduate of an accredited major in chemical engineering or the equivalent. Graduates of other accredited engineering or physical science majors may be admitted but will be required to make up certain undergraduate deficiencies without graduate credit. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available

for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

CHEMICAL ENGINEERING (CH E)

404. Chemical Engineering Economics (3)
405. Thermodynamics for Chemical Engineers (3)
406. Chemical Engineering Problems (3)
410. Chemical Engineering Principles (3)
411. Chemical Engineering Principles (3)
412. Chemical Engineering Principles (3)
415. Analysis and Mathematical Simulation in Chemical Engineering (3)
420. Cryogenic Engineering (3)
422. Modern Petroleum Technology—Processes and Products (3)
426. Introduction to Transport Phenomena (3)
430. Nuclear Chemical Engineering (3)
435. Chemical Reaction Kinetics (2)
440. Chemical Engineering Materials (3)
445. Chemical Engineering Research (1-5)
450. Process Dynamics (3)
460. Chemical Engineering (4)

500. Seminar in Chemical Engineering (1) Required of all graduate students.

508. Principles of Industrial Organic Chemistry (3) Principles and practices of modern conversion processes in the manufacture of organic chemicals. Prerequisites: Chem. 31, 452; Ch.E. 30.

509. Heat Transfer Applications (3) Advanced treatment of steady-state and transient conduction, convection, and radiation, with emphasis on numerical methods and design techniques. Prerequisite: an undergraduate course in heat transfer.

515. Distillation (3) Commercial distillation, equilibrium diagrams, vapor composition, stills and rectifying and stripping columns.

516. Methods of Process Design (3) Survey of mathematical techniques of chemical process design with emphasis on economic choice and optimal decision making.

520. Extraction Processes (3) Equilibrium extraction data and phase contacting and settling related to equipment design.

521. Transport Phenomena (3) Momentum, heat, and mass transfer in boundary layers and turbulent fluids; ideal potential flow; unsteady state and coupled transport.

522. Special Topics in Transport Phenomena (3) Intensive group study and discussion of current problems and techniques in transport processes. Prerequisite: Ch.E. 521.

524. Chemical Engineering, Application of Thermodynamics (3) Elements of thermochemistry and thermodynamics of greatest importance in chemical engineering.

535. Chemical Reaction Engineering (3) Optimal design of batch and continuous chemical reactors and reactor batteries; effect of mixing on reactor operation. Prerequisite: Ch.E. 435.

CHEMISTRY (CHEM)

JOSEPH A. DIXON, *Head of the Department*
212 Whitmore Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Allcock, Ascah, Benkovic, Bernheim, Deno, Dixon, Fritz, Gold, Haas, Hamilton, Hayes, Heicklen, Hisatsune, Horrocks, Jackman, Jordan, Lampe, Lowe, Miller, Olofson, Richey, Rosenblatt, Schempf, Shamma, Skell, Steele, Wartik, and Zook.

Graduate Faculty: Associate Members Crawford, Goncalves, Jurs, Lotz, Riehl, Seeley, Stanko, and Villafranca.

Students may specialize in analytical, inorganic, organic, or physical chemistry. The general facilities are excellent, and the computer, cryogenic, radiochemical, and spectroscopy laboratories provide unusual research opportunities. Distinguished visiting scholars conduct informal discussion each Thursday at a departmental colloquium. The department requires a knowledge of German as a condition for awarding either the M.S. or Ph.D. degree. Candidates who have taken and passed two undergraduate courses in German will be certified as having completed the communication and foreign language requirement. For the M.S. degree the student has the option of writing a thesis or a paper.

For admission, at least integral calculus plus one year's work in general physics, organic chemistry, physical chemistry, and either analytical or inorganic chemistry is normally required. Students who have appropriate course backgrounds and who present a 2.50 average in all undergraduate courses in chemistry, physics, and mathematics will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Prior to scheduling their first term programs, new students will take examinations in the areas of analytical, inorganic, organic, and physical chemistry. The information obtained from these tests will assist both the student and his adviser in making up a program best suited to the student's needs. These examinations are normally given just prior to the regular registration period.

CHEMISTRY (CHEM)

400. CHEMICAL LITERATURE (1)
401. SEMINAR (1)
405. NUCLEAR AND RADIOCHEMISTRY (3)
408. (Cmp.Sc. 408) COMPUTER APPLICATIONS IN CHEMISTRY (3)
410. INORGANIC CHEMISTRY (2)
411. ADVANCED INORGANIC CHEMISTRY (2)
412. EXPERIMENTAL INORGANIC CHEMISTRY (2)
423. ADVANCED ANALYTICAL CHEMISTRY (3)
424. ADVANCED ANALYTICAL LABORATORY (2)
426. CHEMICAL INSTRUMENTATION (3)
431. ADVANCED ORGANIC CHEMISTRY LABORATORY (3)
435. ADVANCED ORGANIC CHEMISTRY LABORATORY (3)
439. STRUCTURAL ANALYSIS OF ORGANIC COMPOUNDS (3)
448. COLLOID CHEMISTRY (3)
*451-452. PHYSICAL CHEMISTRY (3 each)
453. ADVANCED PHYSICAL CHEMISTRY (3)

* Graduate credit not allowed for students majoring in chemistry or chemical engineering.

454. Advanced Physical Chemistry (3)
455. Physical Chemistry of High Polymers (3)
*457. Experimental Physical Chemistry (2)
*458. Experimental Physical Chemistry (1)
489. Introduction to Chemical Research (1-10)
493. Selected Topics in Chemistry for Teachers (3-9)

500. Seminar in Chemistry (1 per term)

516-517. Inorganic Chemistry (3 each) Systematic treatment of inorganic chemistry in terms of modern concepts.

518. Special Topics in Inorganic Chemistry (3 per term) Modern developments in specialized fields.

525. Analytical Processes (3) Theoretical foundations and contemporary developments.

526. Modern Instrumental Analysis (3)

527. Special Topics in Analytical Chemistry (2-12)

531. Special Topics in Organic Chemistry (3-12) Prerequisite: Chem. 536.

534. Chemical Applications of Quantum Theory (3) A development of Molecular Orbital Theory up to the level of present-day usage in organic and inorganic chemistry.

535-536. Organic Reaction Mechanisms I and II (3 each) Reaction mechanisms and their determination by kinetic and nonkinetic methods. Reactive intermediates. Prerequisite: Chem. 439.

537. Synthesis in Organic Chemistry (3) Theory and methods of directed syntheses, including stereospecific and stereoselective schemes; biologically inspired syntheses. Prerequisite: Chem. 536.

544. Chemical Thermodynamics (3) Development of thermodynamic theory with special reference to common physical changes and chemical reactions. Prerequisite: Chem. 452.

545. Statistical Thermodynamics (3) The calculation of thermodynamic properties from molecular and spectroscopic data. Prerequisites: Chem. 544, 565.

560. Topics in Physical Chemistry (2-6)

563. Chemical Kinetics (3) Theory and measurement of the rates of chemical reactions, molecular dynamics, and mechanisms of chemical reactions. Prerequisites: Chem. 544, 565.

565. Atomic and Molecular Structure (3) Introduction to modern theoretical chemistry, spectroscopy, and structure of atoms and molecules.

566. Quantum Chemistry (3) Theoretical calculations of electronic properties of atoms and molecules. Prerequisite: Chem. 565. Prerequisite or concurrent: Math. 555.

567. Quantum Chemistry (3) A continuation of Chem. 566, including problems and theories of electron correlation. Prerequisite: Chem. 566.

571. Polymer Chemistry (3) The synthesis, reactions, and structure determination of high polymers.

*Graduate credit not allowed for students majoring in chemistry or chemical engineering.

589. Studies in Chemistry (1-9) Theoretical research, experimental research, or a critical survey of the literature in an area of chemistry.

CIVIL ENGINEERING (C E)

Raymond E. Untrauer, *Head of the Department*
212 Sackett Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Barnoff, Cady, Gotolski, Hurd, Larson, McDonnell, Nesbitt, Reich, Taylor, and Whisler.

Graduate Faculty: Associate Members Aron, Atakol, Davinroy, McClure, Mozingo, Unz, Weeden, and West.

Students may specialize in structures, hydraulics, hydrology, transportation engineering, traffic engineering, materials, soils, and sanitary engineering, or combinations of these. Relevant courses are offered both by the Department of Civil Engineering and by other departments of the University.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by a reading, writing, and speaking ability in English and a reading knowledge of an acceptable foreign language.

Candidates normally should be graduates in engineering from an accredited college of engineering. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

See also Sanitary Engineering.

CIVIL ENGINEERING (C E)

400. Seminar (1-3)
401. Civil Engineering Projects (2-12)
421. Highway Engineering (3)
422. Transportation Engineering (3)
423. Traffic Characteristics and Measurements (3)
424. Civil Engineering Materials (3)
431. Civil Engineering Construction (3)
446. Advanced Soil Mechanics (3)
447. Structural Analysis by Matrix Methods (3)
448. Advanced Structural Design (3)
451. Advanced Hydrology (3)
452. Water Resources and Computations (4)
462. Open Channel Hydraulics (3)
465. River and Waterways Engineering (3)
471. Environmental Sanitation (3)
472. Water Pollution Control (3)
476. Solid Waste Management (3)

500. Seminar in Civil Engineering (1-6) Reports on researches and special topics. Course may be continued in subsequent terms.

501. Civil Engineering Projects (3-10) Investigation or design projects in structures, transportation, hydraulics, or civil engineering materials.

511. Engineering Soil Characteristics (3) Physical and chemical factors in soil which influence their engineering properties of strength, deformation, permeability, and soil stabilization.

512. Applied Soil Mechanics (2-5) Soil classification by type of clay minerals and profile development; aerial photographic interpretation of soils and applications to site selection for dams, highways, and airports.

513. Soil Exploration and Analysis (3) Laboratory evaluation of parameters used in modern soil mechanics. Involved techniques of soil testing, test limitations, sampling influences, technical reports.

519. Traffic Administration and Finance (2) Organization and administration of traffic engineering at various levels of government; leaders in the highway transportation field are guest lecturers.

520. Pavement Design (3) Fundamental principles; properties of pavement components; design tests; design of flexible pavements; design of rigid pavements; pavement evaluation and strengthening.

521. Techniques of Transportation Analysis (2-4) Transportation functions, travel patterns, basic analytical methods in the planning content.

522. Highway Operations (2) Theory and application of traffic controls, including functional operations of traffic signals, systems, and networks; the design of highway lighting.

523. Urban Transportation Planning (2-4) The problem in historical perspective, current content, costing procedures, public policy, the planning process.

524. Advanced Problems in Civil Engineering Materials (2-6) Study, in the literature and by laboratory investigation, of selected topics on field-controlled civil engineering materials. Prerequisite: C.E. 424.

525. Airport Planning and Design (3) Aircraft characteristics; aeronautical demand; site selection; airport configuration; capacity analysis; design of landing and terminal areas.

526. Design of Transportation Facilities (3) Basic principles and engineering design of truck terminals, railroad yards and terminals, bus terminals, and parking facilities.

527. Theory of Traffic Flow (3) Phenomenon of vehicular traffic flow; flow density relationships; spacing; gap counting; delays; problems involving interrupted flow; multiflow routes.

528. Queuing Models in Transportation (3) Arrival patterns; the service mechanism; queue discipline; delays; multiple queues; problems involving various combinations of queues and service facilities.

529. Highway Geometric Design (3) Principles of road and parking terminal design with emphasis on operations; highway planning related to alternate solutions of design problems. Prerequisites: C.E. 423, 522.

533. Ultimate and Plastic Design Methods (3) Plastic design of steel structures. Limit design of concrete structures. Ultimate theories applied to plate and slab problems.

537. Matrix Method of Structural Analysis (3) Analysis of structures using advanced matrix techniques, transformation of matrices, energy concepts, iterative solutions, applications to linear and nonlinear structures. Prerequisite: C.E. 447.

539. Approximate Methods of Structural Analysis (3) Newmark's method, finite difference method, and finite element method applied to problems in structural and soil engineering.

540. Advanced Structural Analysis I (3) Analysis of continuous beams, frames on elastic supports, grids, and arches under various loading conditions. Influence lines and deformations.

541. Advanced Structural Analysis II (3) Redundant, continuous, hybrid trusses, influence lines; secondary stresses; framed arches; suspension systems, selection of bridge type; space framing.

544. Advanced Design of Concrete Structures (3) Concrete working stress, ultimate strength, limit design; test behavior of beams, slabs, columns; simple and continuous prestressed concrete members.

545. Advanced Structural Design (2-4) Steel, aluminum members; flexible connections; composite, hybrid, prestressed beams; tension-field beams; buckling; plastic analysis, design; test data; timber design. Prerequisite: C.E. 41.

546. Thin Concrete Structures (3) Design of thin concrete structures including slabs, folded plates, and shells.

548. Structural Design for Dynamic Loads (3) Dynamic behavior of structural systems of one and more degrees of freedom; earthquake, blast-resistant analysis, and design of structures.

549. Long Span Structures (3) Analysis and design of suspension bridges, cable roofs, and arch-type structures.

550. Engineering Construction Management (2-4) Management fundamentals for construction contracting; organization, project planning, scheduling and control, bonding and insurance, labor legislation and regulation, cost and control. Prerequisite: C.E. 431.

551. Hydrologic Investigations (2-8) Application of hydrologic principles and techniques to a specific project.

552. Hydrologic Processes and Cybernetics (3) Application of cybernetic concepts in electronic computer simulation of the hydrologic process-components: infiltration, precipitation, evapotranspiration, and overland flow. Prerequisite: C.E. 51 or 452.

553. Planning Multipurpose Hydrologic Systems (3) Study of multipurpose hydrologic schemes within a social, economical, and political framework. Prerequisite: C.E. 451 or 452.

554. Urban Hydrology (3) Several hydrograph methods. Design storm and IUH application; airport drainage; flood planes; impact of urbanization upon groundwater and sediment. Prerequisite: C.E. 451 or 452.

560. Dimensional Analysis and Theory of Models (3) Principles of dimensional analysis and similitude with engineering applications.

564. Hydraulic Engineering Design (2-8) Design and analysis of selected units of a typical hydraulic engineering project.

565. Transportation of Solids by Fludis (2-5) Fundamentals of the flow of solids in open and closed conduits; e.g., suspended load and bed load in rivers, slurries and pulp stocks in pipes.

571. Water Treatment Theory (3) Theory of modern methods of conditioning water for municipal and industrial use. Prerequisite: C.E. 472.

572. Waste Treatment Theory (3) Theory of modern methods of waste treatment. Prerequisite: C.E. 472.

573. Problems in Environmental Pollution Control (3-9) Investigations, analyses, and reports on current topics in environmental pollution control.

574. Laboratory Analyses in Water Quality Control (3) Experiments illustrating current chemical and biochemical methods of water and waste treatment and analytical methods used in research and control.

575. Advanced Industrial Waste Treatment (3) Techniques of industrial waste treatment; attendant stream pollution and stream self-purification factors. Prerequisite: C.E. 472 or 572.

576. Water Treatment Plant Design (1-6) Design of works for treatment of water for municipal and industrial use. Prerequisite: C.E. 71.

577. Waste Treatment Plant Design (1-6) Design of works for the treatment of municipal or industrial wastes. Prerequisite: C.E. 71.

579. (Micrb. 529) Aquatic Microbiology (3) Ecology and physiology of microorganisms of inland waters, estuaries, and oceans; microbiology of wastewater treatment. Prerequisite: introductory microbiology.

580. Stream and Estuarine Analysis (3) Quantitative assessment of advection, reaction, and dispersion processes in polluted waters; reaeration theory; eutrophic systems; analog simulation. Prerequisite: C.E. 472.

CLASSICS (CLASS)

Anthony J. Podlecki, *Head of the Department*
104 Carnegie Building

Degree Conferred: M.A.

Graduate Faculty: Senior Members Carrubba and Podlecki.

Programs leading to the master's degree in this major offer opportunities for specialization in either Latin or Greek, or a combination of both. The minimum requirement for admission to either program will normally be 18 undergraduate credits in either language. Provision is made, however, for admission with limited deficiencies. Candidates may either submit a thesis or schedule 6 additional credits in 500-level courses in the major field.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

GREEK (GREEK)

401. Introductory Readings in Greek Literature (3)
420. The Greek Historians (3)
421. Greek Tragedy (3)
422. Greek Comedy (3)
425. Homer (3)

430. The Greek Philosophers (3-9)
431. Plato (3)
450. Topics in Greek Literature (3-6)
451. History of the Greek Language (3)
489. Studies in Greek Literature (1-6)

502. Greek and Latin Epigraphy (3) Study of the techniques of epigraphical research; the value of inscriptions for Greek and Roman history and private antiquities.

507. Problems in Greek Archaeology (3-9)

509. Greek Seminar (3-9)

517. Greek Research (1-6) Prosecution of an assigned problem under the guidance of a member of the department.

LATIN (LATIN)

420. The Latin Historians (3)
425. Latin Elegy (3)
426. Roman Comedy (3)
427. Vergil (3)
428. Lucretius (3)
430. Medieval Latin (3-6)
431. Roman Satire (3)
432. Roman Rhetorical and Literary Theory (3)
436. The Teaching of Latin (3)
437. Latin Prose Composition (3-6)
460. Topics in Latin Literature (3-6)
461. History of the Latin Language (3)
489. Studies in Latin Literature (1-6)

500. Latin Literature (3-9) Readings in the major forms of Latin literature; content varies, course may be repeated.

501. Roman Religion and Philosophy (3) Development of religious concepts at Rome from primitive Italic origins to the advanced forms that culminated in Roman Stoicism. Prerequisites: two 400-level courses in Latin.

510. Latin Seminar (3-6)

518. Latin Research (1-6) Prosecution of an assigned problem under the guidance of a member of the department.

*CLASSICS (CLASS)

405. Greek and Roman Mythology (3)
406. Emergence and Development of Classical Poetic Genres (3)
408. Greek Religion and Modern Man (3)
410. Classical Epic (3)
411. Classical Drama (3)
412. Classical Historians (3)
413. Readings in Classical Literature (3)

* The readings are in English; knowledge of Greek and Latin is not required.

500. Introduction to Classical Scholarship (1-6) Lectures on the methods and materials of classical scholarship. To be scheduled by graduate students in their first term, and as necessary thereafter.

504. Topography of Ancient Rome (3) Lectures and readings on physical development of the ancient city of Rome from earliest habitation to time of later empire.

COMPARATIVE LITERATURE (C LIT)

Robert Lima
In Charge of Graduate Programs in Comparative Literature
N-346 Burrowes Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Bayard, Carrubba, Hyslop, Lewis, Lima, Rosenberg, Shelley, Weintraub, and West.

Graduate Faculty: Associate Members Begnal, Knight, and Walden.

Programs of study in international literary and cultural relations are arranged in accordance with the individual student's interests through a meaningful selection of courses both in comparative literature and in the several national literatures. Topics appropriate to such programs include the currency, reception, and influence of writers and works in countries other than those of their origin; the origin, transmission, and evolution of international literary movements; the characteristics and relations of genres, themes, and motifs; folk literature and folklore; criticism; aesthetics; intermediaries; relationships between literature and other disciplines.

In addition to the general requirements for graduate degrees, there are the following special requisites: *Master of Arts*—Courses in comparative literature (9 credits) and two national literatures (9 and 6 credits), knowledge of the language of each of the two literatures to be demonstrated by examination, a written examination, and a thesis (6 credits). *Doctor of Philosophy*—The communication and foreign language requirement for the Ph.D. degree may be satisfied by courses in comparative literature (18 credits) and three national literatures (24, 12, and 12 credits), one of which may be English, knowledge of the languages of each of the three literatures to be demonstrated by examination, a written examination, and a doctoral thesis. Pertinent courses taken for the M.A. degree may be applied toward Ph.D. requirements.

Admission requirements to the program in comparative literature include an appropriate degree in literature or a related discipline, together with a strong background in at least one foreign language. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

COMPARATIVE LITERATURE (C LIT)

401. Western Literature I (3) *Mrs. Eckhardt*
402. Western Literature II (3) *Mr. Knight*
403. Western Literature III (3) *Mr. Begnal*
408. Heroic Epic and Song (3) *Mr. Bayard*
420. Tradition in Modern African Literature (3) *Mr. Michelman*
421. Modern African Literature: The Colonial Experience (3) *Mr. Michelman*

443. (Ger. 443) Literary Relations of Germany with England and America (3-9) *Mr. Shelley*
470. Old Masters of the Modern Novel (3) *Mr. Begnal*
480. Introduction to Folklore (3) *Mr. Rosenberg*
486. Tragedy (3)
487. Comedy (3) *Mr. Knight*
488. (Engl. 488) Modern Continental Drama (3) *Messrs. Christopher and Grecco*
489. Special Subjects and Problems of Comparative Literature (3) *Staff*

500. Seminar in Comparative Literature (3-6) *Staff*

501. Comparative Method in Literary Studies (3) *Staff*

508. Norse and Gaelic Sagas (3) Medieval Irish and Scandinavian prose tales surveyed and compared with respect to backgrounds, development, themes, and characteristics. *Mr. Bayard*

570. Forces in Contemporary European Literature (3) The intellectual currents that have influenced European writers of the mid-twentieth century: Beckett, Böll, Robbe-Grillet, and others. *Mr. West*

588. Twentieth-Century Drama (3) The comparative analysis of major plays of the twentieth century. *Mr. Lima*

593. (Engl. 593) Anglo-American Folk Song (3) Survey of relevant literary and ethnological scholarship and field work, European and American, from the early sixteenth century to the present. *Mr. Bayard*

COMPUTER SCIENCE (CMPSC)

Preston C. Hammer, *Head of the Department*
426 McAllister Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Coffman, Day, deMaine, Gotterer, Hammer, Hsu, and Laird.

Graduate Faculty: Associate Members Barnes, Campbell, Honkanen, Hosken, Johnson, Jones, and Squires.

The department offers courses and is prepared to direct research in a variety of subfields of computer science, including information retrieval, theoretical foundations of computer science, computer languages and programming systems, numerical analysis and nonnumeric procedures. The Computation Center has modern digital equipment and systems available for research and instruction.

Admission to the M.S. program without deficiency requires the equivalent of Cmp.Sc. 401 and 410 and at least four of the six following: (1) Cmp.Sc. 404, (2) Cmp.Sc. 411, (3) Cmp.Sc. 420, (4) Cmp.Sc. 453 or 454, (5) Cmp.Sc. 468, (6) Math. 63 and 441. The remainder of these six must be completed for the M.S. and Ph.D.

The M.S. candidate must satisfactorily complete Cmp.Sc. 510, 511, and 540, in addition to the other requirements of the Graduate School. The non-thesis option is available for the M.S. degree.

The Ph.D. degree is primarily a research degree, and is conferred on the basis of original work and high academic achievement in computer science. In order to be accepted as a candidate the student must pass a six-hour written candidacy examination. The communication and foreign language requirement for the Ph.D. degree may be satisfied by a proficiency in one foreign language (French, German, or Russian). These and additional requirements are detailed in the departmental brochure, *Computer Science at Penn State.*

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

COMPUTER SCIENCE (CMPSC)

401. Principles of Programming with Physical Science Applications (3)
402. Principles of Programming with Social and Biological Science Applications (3)
403. Principles of Programming with Business Applications (3)
404. Information Structures (3)
408. (Chem. 408) Computer Applications in Chemistry (3)
410. Introduction to Computer Systems (3)
411. Systems Organization and Programming (3)
420. The Structure of Programming Languages (3)
430. Combinatorics and Graph Theory (3)
450. Information Theory and Error-Correcting Codes (3)
453. (Math. 453) Numerical Computations (3)
454. (Math. 454) Matrix Computations (3)
468. Mathematical Machine Theory (3)
490. Special Topics in Computer Science (1-9)
491. Computer Projects (3)

500. Theory of Automata (3) The structure of finite automata and sequential machines including characterization theorems, minimization problems, state identification experiments and decomposition theory. Prerequisite: Cmp.Sc. 468.

501. Algebraic Theory of Automata (3) Prerequisite: Cmp.Sc. 500.

510. Structure of Artificial Languages (3) Structure of problem-oriented languages; syntactical description, algorithms for translation, list structures, string manipulation, formula manipulation, relation to linguistics. Prerequisites: 3 credits in logic or logical design at the 400 level, Cmp.Sc. 420.

511. Systems Programming (3) Interpretive systems; assemblers, loaders, compilers, library monitor systems; input-output scheduling; executive programs, job scheduling; multiaccess systems, multiprogramming, multiprocessing. Prerequisites: Cmp.Sc. 404, 420.

530. Nonarithmetic Programming (3) Combinatorial problems, learning mechanisms, heuristic programs, and pattern recognition. Prerequisite: Cmp.Sc. 420 or 485.

535. Theory of Graphs and Networks (3) Theory and applications of graphs including structure of graphs, network analysis and algorithms for computer solution of graph-theoretic problems. Prerequisite: Cmp.Sc. 430.

537. (B.A. 537) Management Information Systems Design (3) Cost, value, and technical considerations in analysis and design of information systems whose purposes are to aid decision making in organizations.

540. Information Processing Systems (3) Data structures and data processing; information retrieval systems. Prerequisite: Cmp.Sc. 404.

545. Information Retrieval (3) This course deals with input-output, design implementation, evaluation, global memories and comparison of information retrieval systems. Prerequisite: Cmp.Sc. 540.

552. (Math. 552) Numerical Analysis I (3) Interpolation; remainder theory; approximation of functions; error analysis; orthogonal polynomials; approximation of linear functionals; functional analysis applied to numerical analysis. Prerequisites: Math. 420, 453.

553. (Math. 553) Numerical Analysis II (3) Eigenvalue and eigenvector determination; numerical solution of integral equations and ordinary differential equations with error and stability analysis. Prerequisites: Math. 420, 454 or 480.

559. Computability and Recursive Functions (3) Mathematical treatment of computability, recursive functions, Turing machines, unsolvable problems, recursive and recursively enumerable sets. Prerequisite: Cmp.Sc. 468.

560. Combinatorial Systems (3) The relationships among various forms of combinatorial systems including Turing machines, Post normal systems, Thue systems and recursive functions. Prerequisite: Cmp.Sc. 559.

563. (Math. 563) Aproximation Theory (3) Approximation in normed spaces; existence, uniqueness, characterization, computation of best approximations; error bounds, degree of approximation; approximation of linear functionals. Prerequisites: Math. 453, 501.

564. (Math. 564) Numerical Solution of Partial Differential Equations (3) Numerical solution of initial and boundary-value problems; eigenvalues and eigenfunctions; errors, stability, and convergence. Prerequisite: Math. 552.

566. (E.E. 566) Algebraic Coding Theory (3) Polynomial rings, galois fields, linear codes, cyclic codes, BCH codes, finite projective geometry cyclic codes, convolution codes, graph theoretic codes. Prerequisite: Cmp.Sc. 450 or E.E. 561.

568-569. Theory of Formal Languages and Automata (3 each) Generation and recognition of formal language, grammar, Chomsky's hierarchy of languages, closure properties, characterization by automata, algebraic properties, complexity classification. Prerequisite: Cmp.Sc. 468.

579. (Math. 579) Special Topics in Numerical Analysis (2-12)

591. Special Topics in Computer Science (2-6)

592. Special Topics in Foundations (2-6)

593. Special Topics in Languages and Systems (2-6)

594. Special Topics in Nonnumerical and Self-improving Systems (2-6)

COUNSELOR EDUCATION (CN ED)

Edwin L. Herr, *Head of the Department*
323 Social Sciences Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Herr, Hudson, Hylbert, and Wellington.

Graduate Faculty: Associate Members Britton, Kelz, Swisher, Upcraft, and Warner.

Professional preparation is offered at the master's level for school counselors (elementary and secondary), college counselors or persons entering college student personnel services, and rehabilitation counselors. Doctoral programs prepare candidates for positions of responsibility and leadership in these same areas as well as in the education of counselors. Doctoral candidates must have a minimum of one year's work experience in their field.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign languages.

All candidates for graduate degrees in counselor education must present for admission at least 27 undergraduate credits of 3.00 or better distributed among at least three of the following areas: economics, education, psychology, sociology, and physiology or anatomy.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. Doctoral candidates should present a 3.33 average in all graduate study completed and a satisfactory score on the Miller Analogies Test, Counselor Education Achievement Test, and the Ohio State Psychological Examination.

All candidates are expected to exhibit, in addition to academic competence, effectiveness in interpersonal relations and in both written and oral communication. They must also evidence support of professional counseling activities and organizations.

A candidate for either a Ph.D. or a D.Ed. must earn at least 30 credits in six or fewer consecutive terms in residence after completing the master's degree, preferably at the thesis planning and writing stage.

COUNSELOR EDUCATION (CN ED)

403. Foundations of Guidance and Counseling Processes (3)
404. Group Procedures in Guidance and Counseling (3)
408. Introduction to Vocational Rehabilitation (3)
409. Medical Information for Counselors (3)
410. Rehabilitation of the Mentally Ill (3)
412. Rehabilitation Facilities and Services of Pennsylvania (3)
413. Rehabilitation Case Recording and Management (3)
425. The Use of Tests in Counseling (3)

501. Counseling: Theory and Method (3) Theory and methods of counseling individuals whose problems of choice, decision, and adjustment fall within the normal range. Prerequisite: Cn.Ed. 403 or 408 or 551.

503. Guidance Services in Elementary Education (3) Guidance services to elementary school students; guidance opportunities for elementary teachers and principals. Prerequisite: Cn.Ed. 403.

504. Guidance Services in Secondary Education (3) Nature and scope of guidance in secondary schools—services, models, and strategies; the counselor as an agent of change. Prerequisite: Cn.Ed. 403.

505. Foundations of Counseling Information (3) Accelerating change in economic, psychological, social, educational influences upon counselees. Utilization of information systems in effecting counselee change. Prerequisite: Cn.Ed. 403 or 408 or 504 or 551.

506. Individual Analysis and Counseling Procedures (3) Collection and use of data basic to the counselor's understanding of individuals; the counseling interview and techniques other than testing. Prerequisites: Ed.Psy. 451 and Cn.Ed. 408 or 503 or 504.

507. Counseling Practicum (1-6) Practice in the application of guidance principles and methods to cases counseled under supervision; case conferences; seminar in guidance techniques. Prerequisite: Cn.Ed. 506.

508. Organization and Administration of Guidance Programs (3) Principles, organization, personnel, functions, integration with school programs, evaluation. Prerequisite: Cn.Ed. 506.

509. Contributions of Professional Personnel to Vocational Rehabilitation (3) Contributions of medical, social, psychological, and other specialists through the team approach; professional ethics, medical problems. Prerequisites: Cn.Ed. 403, 408.

511. Supervised Practicum in Rehabilitation Counseling (1-6) Application of principles and techniques of rehabilitation counseling to cases involving handicapped individuals. Prerequisites: Cn.Ed. 403, 408.

512. Professional Experience in Rehabilitation Counseling (1-6) Supervised internship with responsibility for a regular case load. Prerequisites: Cn.Ed. 403, 408.

513. Supervision of Counselors (3-9) Practical experience in supervising and evaluating work of counselors. Prerequisite: Cn.Ed. 507.

515. Seminar in Counseling, Guidance, and Rehabilitation (1-9) Conferences and discussions designed to meet the need for special study of particular topics in counseling, guidance, and rehabilitation. Prerequisite: 9 credits in counselor education.

516. Evaluation of Projects in School Guidance (2-6) Implementation and evaluation of program development projects in cooperation with state or local guidance programs. Prerequisite: 15 credits in counselor education.

551. Student Personnel Services (2-3) Student personnel services in higher education; organization of student advisory programs; use of personnel data; co-curricular activities; student welfare.

553. Student Personnel Services Programming (2-3) Formulation of policies as guides to the student personnel service programs; integration of program elements; research; current problems and trends. Prerequisites: Cn.Ed. 551, Hi.Ed. 545.

589. Problems, Projects, and Area Studies in Counselor Education (1-6) Independent work in the study of topics in counselor education, or development of new curriculums, materials, or procedures for teaching.

591. Seminar in Counseling: History and Trends (1) Discussion of the history of guidance and counseling, emphasizing how the past has shaped the present and protends the future. Prerequisite: 9 credits in counselor education.

592. Seminar in Counseling: Legal and Ethical Concerns (1-2) Study and discussion of legal, ethical, and professional concerns of counselors; privileged communication, data banks, and privacy invasion. Prerequisite: 9 credits in counselor education.

593. Seminar in Counseling: Philosophy (1) Study and discussion of such philosophical foundations of counseling as phenomenology, idealism, realism, existentialism, daseinanalytic, theological, and other contemporary thoughts. Prerequisite: 9 credits in counselor education.

DAIRY SCIENCE (D SC)

DONALD V. JOSEPHSON, *Head of the Department*
111 Borland Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Almquist, Amann, Flipse, Josephson, Keeney, Kesler, McCarthy, Patton, Tanabe, and Watrous.

Graduate Faculty: Associate Members Buckalew, Hargrove, Shellenberger, and Thoele.

Students may specialize in dairy products manufacture, chemistry of milk and dairy products, lipid metabolism, dairy cattle nutrition, dairy cattle genetics, dairy cattle management, and physiology of reproduction. The minor program is generally taken in biochemistry, microbiology, physiology, or agricultural economics. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Prerequisite to graduate work is the completion of an undergraduate major in animal industry, animal science, dairy science, food technology, or a related area. The undergraduate program must include college algebra and general physics. Students may be admitted with limited deficiency but are required to make up undergraduate deficiency work without degree credit.

Students with a 2.70 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.70 grade-point average may be made for students with special backgrounds, abilities, and interests.

DAIRY SCIENCE (D SC)

405. DAIRY CATTLE MANAGEMENT (3) *Mr. Buckalew*
418. DAIRY SURVEY (1) *Mr. Shellenberger*
427. MILK SECRETION (3) *Mr. Kesler*
428. DAIRY PRODUCTION PROBLEMS (1-6) *Mr. Kesler and Staff*
431. PHYSIOLOGY OF REPRODUCTION IN FARM ANIMALS (3) *Messrs. Almquist and Amann*

507. DAIRY CATTLE MANAGEMENT (1-6) *Mr. Buckalew and Staff*

508. DAIRY SEMINAR (1-6) Preparation and presentation of a paper on an assigned subject.

511. DAIRY CATTLE NUTRITION (1-6) Nutritional requirements of dairy cattle. Prerequisite: A.Ntr. 401. *Mr. Kesler*

512. ADVANCED STUDIES IN MILK SECRETION (1-6) Physiology of milk secretion. Prerequisite: D.Sc. 427. *Mr. Kesler*

513. DAIRY CATTLE BREEDING (1-6) Interpretation and application of current knowledge in genetics to dairy cattle breeding and selection. Prerequisites: An.Sc. 322, Biol. 422, 3 credits in statistics.

515. ADVANCED PHYSIOLOGY OF REPRODUCTION IN FARM ANIMALS (1-6) *Mr. Almquist*

516. ARTIFICIAL BREEDING OF FARM ANIMALS (1-6) Prerequisite: D.Sc. 431. *Mr. Almquist*

517. Dairy Science Literature (1-6) Review and reporting of dairy literature. *Staff*

521. Dairy Radiophysiology (3) Metabolism and physiology of radioactive compounds; their use as tracers in animal physiology and the effects of radiation on metabolic processes. Prerequisite: Chem. 405. *Mr. McCarthy*

Note: *See Animal Science under "Other Elective Graduate Courses." Also see Food Science.*

DEVELOPMENTAL AND REMEDIAL READING (D R R)

Arthur W. Heilman
In Charge of Graduate Program in Developmental and Remedial Reading
230 Cedar Building

Degree Conferred: M.Ed.

Graduate Faculty: Senior Members Bliesmer and Heilman.

The purpose of the master's program is to prepare classroom teachers in elementary and secondary schools for more effective teaching of reading and to provide preparation for supervisory and administrative positions relative to reading in school systems.

Candidates for a master's degree must meet the requirements for admission to graduate study and, in addition, (1) must hold, or be eligible to hold, a valid teaching certificate (persons not meeting this criterion may work on overcoming deficiencies; graduate credit, but not degree credit, may be received for graduate courses taken to overcome such deficiencies) and (2) must have had at least one year of teaching experience or the equivalent.

The master's program has been planned so that those completing the program will also meet the state requirements for "reading specialist" certification.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

DEVELOPMENTAL AND REMEDIAL READING (D R R)

441. Fundamentals of Reading Instruction (3)
442. Reading Problems in the Secondary Schools (2)
444. Practicum in Elementary Remedial Reading (3)
445. Practicum in Secondary Remedial Reading (3)
446. Remedial Reading in the Classroom (3)

545. Diagnostic Testing in Reading (3) Practicum in diagnosing reading difficulties, elementary and secondary levels; achievement, diagnostic, and capacity tests; informal inventories; genesis of reading problems. Prerequisites: El.Ed. 443 and D.R.R. 444 or 445.

546. Reading Instruction (3-6) Research, procedures and materials in reading readiness, word perception, basic reading skills, vocabulary development, reading in content subjects. Prerequisite: 6 hours of graduate credit in D.R.R.

557. Practicum: Remedial Procedures and Diagnosis (3-6) Advanced practicum; diagnostic testing and remedial instruction of more severe types of reading disability; newer and special materials and procedures. Prerequisite: D.R.R. 545.

559. Studies of Research in Reading (3) Intensive study of research in such areas as vocabulary; readiness; instructional approaches; rate; measuring capacity; readability; difficulty causes; sex differences. Prerequisite: 6 hours of graduate credit in D.R.R.

580. Studies in Developmental and Remedial Reading (1-6) Independent and intensive study of topics in reading which relate to research, instructional trends, new materials and total curricular programs. Prerequisite: 9 hours of graduate credit in D.R.R.

EARTH SCIENCES (EARTH)

E. Willard Miller
Chairman of the Committee on Earth Sciences
101 Mineral Sciences Building

Degrees Conferred: D.Ed., M.Ed.

Graduate Faculty: Senior Members Blackadar, Cuffey, Dutton, Guber, Hovermale, Lavin, Lewis, Miller, Panofsky, Thornton, Weber, Wernstedt, Williams, and Wright.
Graduate Faculty: Associate Members Lavoie, J. Pena, and R. Pena.

The M.Ed. program is designed to meet the needs of science teachers in secondary schools. The fields of study are astronomy, geography, geology, geophyics, meteorology, and mineralogy. The student selects one of the earth sciences as an area of concentration, takes at least 12 credits in it, and is required to write a term paper in that area. An additional 12 credits must be taken in at least two other fields of earth sciences, or in two earth science fields plus two courses selected from the biological sciences, chemistry, mathematics, or physics. Furthermore, 6 credits in educational foundations are required as a minor.

The D.Ed. program is designed for secondary school and college science teachers. The major course requirements are designed by the candidate's committee with one area of concentration in the earth sciences plus courses from at least two other earth science areas. The program is designed to investigate problems which arise from the complex interaction of man's technological and social activities with the natural environment. A minimum of 15 credits each is required in professional education and in thesis research.

Students with a 2.50 junior-senior average, 18 credits in education and related psychology, and with other appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

The following courses offered by the various departments are appropriate for students majoring in the earth sciences: Astro. 430; Geog. 433, 434; Geol. 400, 401, 402; Gphys. 400; Meteo. 400, 401, 402, 403, 404; Min. 402.

EARTH SCIENCES (EARTH)

400. Earth Sciences Seminar (3)

500. Earth Sciences Research (1-6) Relationships between the earth sciences revealed by theory, analytical methods, or a selected problem.

ECOLOGY (ECLGY)

EDWIN L. COOPER
In Charge of Graduate Programs in Ecology
315 Life Sciences I Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members P. Baker, Bellis, Butler, Cooper, Cuffey, Dunson, Guber, Hutnik, Kim, McDonnell, Patil, Rothenbacher, Schein, Wagner, and F. Williams.

Graduate Faculty: Associate Members Adams, Costantino, DeWalle, Graves, Lindzey, and A. Williams.

This intercollege program emphasizes the properties of ecosystems by focusing attention on interactions of single organisms, populations, and communities with their environment. It is designed to give students a basic understanding of ecological theory and is, therefore, complementary to other environmental programs which emphasize man's role in ecosystems.

The instructional program includes three graduate core courses in ecology, augmented by an additional integrated group of seminars and courses selected for each student by his committee, and a research project directed by the thesis adviser. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language. The nonthesis option is available for the M.S. degree.

The program is administered by a committee drawn from faculty members in several departments and colleges of the University. This committee and its chairman are appointed by the Dean of the Graduate School. The instructional staff is composed of participating faculty in those departments offering graduate courses in fields closely allied to ecology.

The committee appointed by the Graduate School for each candidate in ecology is selected from members of the program committee and faculty from the student's area of specialization. The committee has the responsibility for determining the course program and research acceptable in satisfying degree requirements.

Students meeting the admission requirements of the Graduate School will be considered up to the number of spaces available in selecting candidates in this program. Candidates should have a strong science background including chemistry, physics, and mathematics. Preparation in biological sciences is also desirable. Students with a unique background in another discipline which has potential value to original ecological work will be seriously considered.

Detailed descriptions of courses now available for students majoring in ecology may be found under the offerings of several departments: Agro. 422; Anthy. 502-503; Biol. 410, 419, 450, 451, 480, 481, 516, 519, 546; C.E. 472, 579, 580; Cmp.Sc. 402; Ent. 403, 416, 517, 535; E.R.M. 410, 413; For. 508, 517; Geol. 430, 503; Meteo. 505; Micrb. 400, 413; Phil. 512; P.Path. 424; Stat. 524; V.Sc. 401; Wildl. 446.

ECONOMICS (ECON)

GRANT N. FARR, *Head of the Department*
613 Kern Graduate Building

Degrees Conferred: Ph.D., M.A., M.Ed.

Graduate Faculty: Senior Members Budd, Coppock, Farr, Hu, Kaufman, Klein, Mason, Myers, Newman, Prybyla, Riew, Robinson, Rozen, Sauerlender, Smith, and Stout.

Graduate Faculty: Associate Members Booms, Cohn, Feller, Fox, Friedrich, Herendeen, and Rodgers.

Opportunities are available for concentration in the following fields: economic analysis, economic doctrines, economic development of developed areas, economic development of underdeveloped areas, economic fluctuations, income distribution, industrial organization, international economics, comparative economic systems, labor economics, money and banking, public finance, quantitative economics, statistics, and regional economics.

Students may also qualify for admission to the program in population issues, consisting of interdisciplinary course work with special emphasis on the economic, social, and geographic issues arising from the dynamics of population change. The communication and foreign language requirement for the Ph.D. degree may be satisfied by an intermediate knowledge of two foreign languages, by substitution of courses from other designated areas for one of these languages, or by a comprehensive knowledge of one foreign language.

The department may waive the requirement of a thesis for M.A. candidates.

To enter graduate work in economics a student should have completed 6 credits in economic principles, 9 in the social sciences, and either 3 in statistics or 6 in mathematics. All applicants must take the Graduate Record Examination in advanced economics and general aptitude.

Students with a 2.50 junior-senior average, a 3.00 average in courses in economics, and appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

ECONOMICS (ECON)

400. History of Economic Thought I (3)
401. History of Economic Thought II (3)
404. Current Economic Issues (3)
405. Advanced Economic Analysis (3)
412. Economics of Collective Bargaining (3)
413. (L.S. 413) Comparative Labor Movements (3)
414. (L.S. 414) Theories of the Labor Movement (3)
415. Social Insurance (3)
418. Economics of Wages and Employment (3)
419. Case Studies in Labor-Management Relations (3)
423. State and Local Taxation (3)
427. (Ed.Adm. 427) Economics of Education (3)
429. Advanced Public Finance (3)
433. International Monetary Economics (3)
435. Labor Relations in the Public Sector (3)
442. Monopoly, Competition, and Their Regulation (3)
450. The Business Cycle (3)
451. Monetary Theory and Policy (3)
461. Economic Growth: Underdeveloped Areas (3)
462. Economic Growth: Theories of United States Development (3)
463. Economic Demography (3)
480. Mathematical Economics (3)
489. Selected Topics in Economics (3)
490. Introduction to Econometrics (3)
491. Analysis of Linear Economic Models (3)
499. Foreign Study in Economics (2-6)

500. Economic Seminar (3-6)

502. Microeconomic Analysis (3) Economic behavior under pure and imperfect competition; price and output determination in product markets; prices and employment in factor markets.

503. Macroeconomic Analysis (3) National income accounts; determination of income, employment, interest rates, and the price level; stabilization policy.

506. Problems in Economics (1-12) Planned individual projects involving library, laboratory, or field work.

507. International Trade (3) A survey of international trade theory including modern developments of pure theory, and of international trade policy.

508. Current Monetary Theory and Policy (3) Post-Keynesian reformulation of quantity and Keynesian theories of money; liquidity and general equilibrium approaches; current issues in theory and policy.

510. Econometrics (3-6) Statistical estimation in mathematically formulated economic relationships.

513. Development of Economic Doctrines (3-6)

515. Economics of the Labor Market (3) Theory and problems of labor-management relations; selected problems of the labor market with reference to current research and developments.

516. Economics of Human Resources (3) Analysis of changes in human resource supply and demand; factors affecting these changes; current human resource policies.

517. International Finance (3) Problems of international liquidity; balance of payments adjustment; international financial institutions and selected policy problems.

518. Development of Monetary Theory (3) Classical and neoclassical quantity theories of money and contemporary criticism; Keynesian monetary theory and its critics.

521. Advanced Microeconomic Theory (3-6) Theory of consumer behavior; theory of the firm; price determination in product and factor markets; introduction to welfare economics.

522. Advanced Macroeconomic Theory (3-6) Measurement of income; theories of consumption, investment, and money holdings; static determination of income and employment; introduction to dynamic analysis.

524. Income Distribution (3) Measurement of inequality; ethical issues in income redistribution; measurement and determination of distributive shares; problem of poverty.

525. Economics of Technological Change (3) Theoretical and empirical analysis of invention and innovation and their effects on productivity, employment, and market structure.

528. Advanced Economic Theory: Selected Topics (3) Treatment of topics in economic theory to meet needs of advanced students seeking intensive work in selected areas.

529. Public Finance (3-6) Contemporary problems in public finance; instruments of fiscal policy in the achievement of full employment, price stability, and economic development.

530. Regional Microeconomics (3) Theoretical and empirical analysis of industrial location as determined by costs, markets, and agglomeration effects.

531. Regional Macroeconomics (3) Aggregate regional trade flows; sources of regional economic data; techniques for measuring regional economic activity; long-run regional growth.

543. Industrial Organization and Public Policy (3) The structure of American industry; performance and behavior; public policies toward business.

550. Economic Fluctuations (3) Analysis of the various theories of economic fluctuations; their methodological premises.

551. Stabilization Policy (3) Description and analysis of the alternatives and issues in stabilization policy.

560. Seminar in Economic Growth: Underdeveloped Areas (3-6) Resources and institutions; quantitative measures; theories of economic growth in developing areas; developmental policies.

561. Seminar in Economic Growth: Developed Areas (3-6) Growth models; strategic factors in growth; quantification problems; public policy.

571. Comparative Economic Systems (3-6) Comparative analysis of alternative resource allocation principles; growth and performance of different economic systems; problems of decision making and control.

572. Soviet and Other Centrally Planned Economics (3-6) Principles, structure, and performance of centrally planned economies with special emphasis on the Soviet Union.

580. Mathematical Economics (3-9) Mathematical development of static and dynamic economic models: partial and general equilibrium analysis; growth dynamics; mathematical programming. Prerequisite: Econ. 480.

595. Seminar in Econometric Theory (3-6) Advanced study in the theories and problems relevant to the application of statistical methods to economics. Prerequisites: 6 credits of Econ. 510 and Math. 409.

EDUCATION OF EXCEPTIONAL CHILDREN (E E C)

Robert M. Smith
In Charge of Graduate Programs in Education of Exceptional Children
307 Cedar Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Anderson, Bliesmer, G. Cartwright, French, Frick, Heilman, McDonald, Siegenthaler, and Smith.

Graduate Faculty: Associate Members Berlin and C. Cartwright.

Exceptional children are those who deviate so far from average in physical, intellectual, emotional, or social characteristics that they cannot profit adequately from the usual public school program. It is the purpose of this program to prepare teachers, researchers, administrators, and college and university teachers in the areas encompassing the education of the mentally retarded, gifted, emotionally maladjusted, neurologically impaired, learning disabled, or crippled. A multidisciplinary approach is

emphasized. The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign languages.

Prerequisites for a master's program include: 10 credits in the education of exceptional children (courses comparable to E.E.C. 400, 401, 403, and 405).

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Applicants for doctoral study shall show evidence of (1) having completed a master's degree with "A" quality grades on at least one-third of the graduate courses and (2) attaining a minimum score of 500 on both portions of the Graduate Record Examination, or 50 on the Miller Analogies Test, or 35 on the Quantitative Educational Device.

EDUCATION OF EXCEPTIONAL CHILDREN (E E C)

400. Introduction to Exceptional Children (3)
401. Educational Adjustments for Exceptional Children (3)
403. Clinical Teaching with Exceptional Children (3)
405. Practicum in the Education of Exceptional Children (1-12)
410. The Mentally Retarded (3)
420. The Mentally Gifted (3)
430. Learning Disabilities (3)
440. (S.P.A. 440) Survey of Speech and Hearing Disorders (3)
454. Diagnosis of Educational Disabilities (3)
470. The Emotionally Disturbed (3)
472. Educational Problems of Urban Alienated Youth (3)
480. The Neurologically Impaired (3)
496. Workshop in Special Education (1-9)

500. Seminar in Special Education (1-9) Continuing series of professional seminars designed to provide a forum for discussion of current and classical research concerning exceptional children. Prerequisites: Ed.Psy. 400 and 6 credits in education of exceptional children.

501. Administration and Supervision of Educational Programs for Exceptional Children (2-3) Problems connected with the instituting and organizing of classes for atypical children; the legal phases, finances, teaching personnel, pupil personnel, housing, equipment, courses of study, curriculum, etc. Prerequisites: E.E.C. 401 and Ed.Ser. 480 or teaching or administrative or supervisory experience.

502. Internship in Special Education (2-10) Internship to take place in schools or educational situations where student is not regularly employed, under supervision of graduate faculty. Prerequisite: E.E.C. 405 or teaching experience.

509. Problems, Projects, and Area Studies in Special Education (1-9) May not be used for thesis credit. Prerequisite: 12 graduate credits in special education.

510. Problems in the Education of the Mentally Retarded (2-4) Study of existing curriculums, instructional practices, educational programs; experimentation in curriculum building and materials construction. Prerequisites: teaching experience and E.E.C. 410.

520. Problems in the Education of the Mentally Gifted (2-4) Analysis of educational needs of mentally gifted; curriculum construction and curricular materials. Prerequisites: teaching experience and E.E.C. 420.

530. Problems in the Education of the Learning Disabled (2-4) Review of the research and theoretical implications in the educational and behavioral management of learning disabled children. Prerequisite: E.E.C. 430.

545. (S.P.A. 545) Cerebral Palsy (3) Etiology and symptomatology of cerebral palsies; diagnosis and treatment of communication problems; the multiprofessional habilitative program. Prerequisite: S.P.A. 444.

547. (S.P.A. 547) Language Disorders in Children (2) Nature, etiology, diagnosis, and management of language disorders in children. Prerequisite: 9 credits in speech pathology and audiology or related fields such as psychology, linguistics, or human development.

554. Psychological and Educational Evaluation of Exceptional Children (3) Administration and interpretation of individual tests other than the Stanford-Binet, WISC, WAIS. Prerequisite: Psy. 559.

570. Problems in the Education of the Emotionally Disturbed (2-4) Prerequisite: E.E.C. 470.

572. Seminar in the Education of Alienated Groups (2) A study of the alienated and educational issues of coping with problems of social, cultural, and economic deprivation. Prerequisite: E.E.C. 472.

573. Problems of Research with Alienated Groups (2) A seminar to review and design research studies for the education and training of alienated groups. Prerequisites: E.E.C. 472, 572.

580. Problems in the Education of the Neurologically Impaired (2-4) Prerequisite: E.E.C. 480.

EDUCATIONAL ADMINISTRATION (EDADM)

Patrick D. Lynch
In Charge of Graduate Programs in Educational Administration
318 Rackley Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members DeLacy, Lutz, and Willower.
Graduate Faculty: Associate Members Caldwell and Lynch.

Professional preparation programs are offered at the master's and doctor's degree levels for elementary and secondary school personnel whose objectives are to become prepared in education policy-making positions such as principals, supervisors, superintendents, intermediate unit officials, state and federal education agency personnel, professors of educational administration, and/or researchers in educational administration.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign and Native American languages.

Requirements for admission to a graduate program in educational administration ordinarily include 18 approved undergraduate credits in education and psychology. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. All applicants for any graduate program, including certification, must submit either a Miller Analogies Test or Graduate Record Examination (Quantitative and Verbal) score. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions

to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

All candidates who seek M.Ed. and M.S. degrees in educational administration shall complete programs embracing a minimum of 30 graduate credit hours. In only rare instances, however, to fulfill unusual objectives will candidates be permitted to work toward the M.S. degree. In Pennsylvania a certification program consisting of at least 45 hours is required before one can become a public school administrator.

Candidates for the D.Ed. and Ph.D. degrees are required to complete a minimum of three consecutive terms in residence.

From the time of initiation of a 600-level thesis research program, all doctoral candidates shall continuously register for a minimum of 2 credits per term until the termination of the graduate program. Failure to register for doctoral thesis credits in any term shall be considered automatic withdrawal. Specific requirements with respect to the Ph.D. and D.Ed. degrees may be learned from a departmental bulletin that is available upon request. Although candidates are required to specialize in a field of educational administration, they are encouraged to acquire a general education in the social sciences and the humanistic foundations.

EDUCATIONAL ADMINISTRATION (EDADM)

427. (Econ. 427) Economics of Education (3)
460. Introduction to Adult Education (3)
480. Educational Administration (2-3)
481. Collective Negotiations in Public Education (3)

528. (Pl.Sc. 528) Politics and Education (3) Social forces which shape the educational system and determine national, state, and local educational policies.

533. The Politics of Local School Districts (3) The methodology of studying political decision making and the theory and practice of politics in local school districts. Prerequisite: 6 credits of sociology, anthropology, or political science.

565. Personnel and Grievance Administration (2-3) Practice and theory of personnel supervision at the central office and building level, including contract administration and grievance handling. Prerequisites: 18 credits in education and three years' teaching experience.

567. Organizational Supervision (3) The organizational context of the school, its relationship to supervision, and the improvement of instruction. Prerequisites: Ed.Adm. 480 and teaching experience.

568. The Principalship (2-3) For elementary and secondary principals. The administrative and management tasks of building administration. The social system, change, and community relationships.

569. Principalship Seminar (2-3) The study and application of interdisciplinary based products and processes in the various organizational units within the educational system.

571. The Educational Plant (2-3) School plant needs in terms of school population and curriculums; the building survey, developing a plant program, the building site, plant utilization, operation and maintenance, heating and ventilation, equipment, school building costs and finance. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.

572. Public Relations for School Administrators (2-3) School-community relationships; social structure, social change, and the schools; case studies of community-school problems. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.

573. Public School Finance (2-3) Financing of public education in relation to organization and control; the conceptual basis for local financial administration; taxation, state and federal aid, school revenue, and money management. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.

574. Theory and Practice of Educational Negotiations (2-3) Theoretical framework, bargaining strategies, legislation, administrative roles, agreements, etc. Prerequisites: Ed.Adm. 480 or teaching or administrative or supervisory experience, and previous work in school administration.

575. Administration of Adult Education in the Public Schools (3) The organization of a program of adult education; its legal status, finances, selection of teachers, learning personnel, housing, and other administrative problems connected with adult education. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.

576. Legal Aspects of School Administration (3) Legal bases for the organization and administration of school districts and schools; the powers, rights, privileges, and responsibilities of school corporations, school boards, administrators, and personnel; the law and fiscal policies; the course of study, textbooks; contracts; taxes, torts; records; agents; and the judicial decisions involved. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.

578. Dynamic Factors in School Administration (2-3) Intraorganizational relationships; administration and the school as a social system; formal and informal organization. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.

579. Public School Business Administration (2-3) Business management applied to school management problems; budgeting, accounting, purchasing, insurance, school equipment, cafeteria management; transportation, salaries, personnel management, and auxiliary and coordinate agencies. Prerequisites: Ed.Adm. 480 or teaching or administrative or supervisory experience; Ed.Adm. 573.

580. The Use of Theory in Educational Administration (1-6) Administrative theories applied to educational organizations. Prerequisites: Ed.Adm. 480, 6 credits in educational administration.

581. Field Research in Educational Administration (2-3) Methods of appraisal of an educational program; planning for expansion, consolidation, or reduction of educational offerings. Prerequisites: Ed.Adm. 480, 6 credits in educational administration.

582. Internship in Administration and Supervision (1-12) Internship to take place in schools or educational situations where student is not regularly employed, under supervision of graduate faculty.

588. Workshop in Current Educational Problems (1-6) For administrators, supervisors, experienced elementary and secondary teachers, guidance workers; administrative, supervisory, and instructional problems involved in an emerging educational program. Prerequisite: 12 credits of graduate work in education.

589. Problems, Projects, and Area Studies in Educational Administration (1-6) Independent work in the study of topics in educational administration, or development of new curriculums, materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of the department head.

591. Seminar in Public School Research (1-4) Doctoral candidates present outlines of their theses to the Graduate Faculty of the department and advanced graduate students.

EDUCATIONAL PSYCHOLOGY (EDPSY)

WILLIAM RABINOWITZ, *Head of the Department*
201 Social Sciences Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members DiVesta, French, Games, Lathrop, Mitzel, Rabinowitz, Seibel, Thevaos, and Withall.

Graduate Faculty: Associate Members Hall, Sanders, Schwartz, Snyder, and Weener.

Graduate work is offered in the general field of educational psychology. Students may specialize and do research in school learning, educational and psychological measurement, statistics and research design as applied to education, and the psychology of instructional systems. Other areas of study related to educational psychology, such as counseling and guidance, clinical psychology, and special education, are offered in other departments of the University.

Doctoral degree requirements include a major emphasis in one of the above areas of educational psychology with minor emphasis in one other related area. Typically, the doctoral program of study would include a minimum of one course in each of the following areas: research methods, educational and/or philosophical foundations, computer science, human learning, measurement, social or industrial psychology, experimental psychology, and developmental psychology. The communication and foreign language requirement for the Ph.D. degree may be met by demonstrating competency in two of the following areas: foreign languages, computer techniques, philosophy of science, and technical writing.

Special facilities include a research design laboratory, a laboratory for computer-assisted instruction, rooms for conducting research projects, facilities for film production and editing, and a closed-circuit television studio used for both research and instruction. Other facilities available to students majoring in educational psychology are the Nursery School, the Psychology Clinic, the Reading Center, the Special Education Center for Children, the Division of Instructional Services, and the Speech and Hearing Clinic. The Computation Center, with several computer systems, is available for use in graduate student research.

Students with a 3.00 junior-senior average and a broad undergraduate background including some college mathematics will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Applicants are required to submit scores on either the Graduate Record Examination or the Miller Analogies Test. Applicants with a master's degree will be required to show more than minimum success in graduate study, including at least one-half of their graduate credits of "A" quality.

EDUCATIONAL PSYCHOLOGY (EDPSY)

400. STATISTICAL INTERPRETATION OF EDUCATIONAL RESEARCH (2)
406. APPLIED PARAMETRIC AND NONPARAMETRIC STATISTICS IN EDUCATION (3)
407. REGRESSION AND CORRELATION METHODS FOR EDUCATIONAL DATA (2)
421. LEARNING PROCESSES IN RELATION TO EDUCATIONAL PRACTICES (3)
450. (Psy. 450) PRINCIPLES OF MEASUREMENT (3)
451. APPRAISAL AND INTERPRETATION OF STANDARDIZED GROUP TESTS (2)
475. INTRODUCTION TO EDUCATIONAL RESEARCH (2)
476. EXPERIMENTATION IN EDUCATIONAL PSYCHOLOGY (3)

501. Current Topics in Educational Psychology (2-6) Study of the current literature in educational psychology with emphasis on historical and theoretical aspects of important areas of investigation. Prerequisites: Ed.Psy. 406, 450, and 421.

506. Advanced Techniques for Analyzing Educational Experiments (3) Advanced techniques for research in education; analysis of covariance; repeated measures; randomized block designs; Latin square; and other experimental arrangements. Prerequisites: Ed.Psy. 406 and 407, or Psy. 415.

507. Multivariate Procedures in Educational Research (3) Introduction to matrix algebra, computer programming, multiple regression analysis, multiple and canonical correlation, multiple discriminant analysis, classification procedures, factor analysis. Prerequisites: Ed.Psy. 406 and 407, or Psy. 415.

512. Group Processes in the Classroom (2) Basic concepts and perspectives in the study of group processes; instructional group interaction; analysis of classroom behavior.

513. Individual and Group Differences (2) Historical and contemporary attempts to relate individual differences to important social and educational issues. Prerequisite: Ed.Psy. 400 or Psy. 15.

518. Contemporary Learning Models in Educational Psychology (3) Contemporary mathematical models and computer simulations of complex human learning occurring in school settings. Modes for analyzing the learning environment. Prerequisite: Ed.Psy. 421.

519. Psychological Foundations for College Teaching (2) Psychological, sociological, and organizational variables which influence college student behavior. Designed for graduate students who anticipate careers in college teaching.

522. Concept Learning in the Schools (2) Study of theory and research related to concept formation and attainment with implications for instruction. Prerequisite: Ed.Psy. 421.

523. Problem Solving in the Schools (2) Examination of theory and research related to cognitive processes in problem solving with implications for educational practice. Prerequisite: Ed.Psy. 421.

524. Theories of Learning and Instruction (3) Study of major classical theories of learning and recent developments in learning and instructional theory. Prerequisite: Ed.Psy. 421.

525. Application of Learning Models to Classroom Practices (2) Probabilistic models of acquisition in complex human learning; assessment of learning in the classroom that is amenable to such analysis. Prerequisite: Ed.Psy. 421.

530. Theory and Research in Programmed Learning (3) Research and trends in programmed learning; preparation of short programmed sequences for experimental analysis. Prerequisites: Ed.Psy. 450 and 421, or Psy. 404.

532. Survey of Media Research (3) Systematic study of media research in educational applications of television, still and motion pictures, graphic and simulated environments. Prerequisite: Ed.Psy. 400 or Psy. 415.

550. Design and Construction of Psychological Measures (3) Lecture-practicum involving planning, construction, administration, and analysis of a psychological test; lectures stress construct validity, item analysis, and predictive validity. Prerequisite: Ed.Psy. 450.

554. Theories of Psychological Measurement (2) Basic true-score and error models; their extensions to test reliability and test validity; problems of item analysis and weighting. Prerequisite: Ed.Psy. 450.

558. Scaling Educational and Psychological Measures (2) Unidimensional and multidimensional scaling models with emphasis on psychometric methods and brief attention to psychophysical methods. Prerequisite: Ed.Psy. 450.

575. Seminar in Educational Psychology (3-9) A seminar dealing with specific topics in educational psychology. Open to advanced students in the behavioral sciences.

591. Problems and Projects in Educational Psychology (1-6) Independent work on special topics.

ELECTRICAL ENGINEERING (E E)

William J. Ross, *Head of the Department*
118 Electrical Engineering East

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Adams, Bredeson, Brown, Cross, Das, Etzweiler, Ferraro, Hale, Holt, Lachs, Lee, Lewis, McMurtry, Mentzer, Nisbet, Quinn, Ross, and Volz.

Graduate Faculty: Associate Members Bishop, Delansky, Fonash, Hulina, Jeffreys, and Robinson.

Course offerings and graduate research opportunities are available in the following areas: automatic control, biomedical engineering, computers, electromagnetics, energy conversion, information systems, ionosphere research, networks and circuits, plasmas, quantum electronics, and solid state electronics.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language. A thesis is required for the M.S. degree.

To be admitted to the M.S. program without undergraduate deficiency, a Bachelor of Science degree in Electrical Engineering, or its equivalent, is required with appropriate courses in electrical circuits, fields, and electronics. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 undergraduate grade-point average may be made for students with special backgrounds, abilities, and interests.

ELECTRICAL ENGINEERING (E E)

401. Network Analysis for Technology Teachers (3)
402. Electronic Devices and Circuits for Technology Teachers, Part I (3)
403. Electronic Devices and Circuits for Technology Teachers, Part II (3)
404. Electromechanical Energy Conversion for Technology Teachers (3)
405. Electronic Instrumentation for Nonelectrical Engineers and Scientists (3)
411. Principles of Electromagnetic Fields (3)
413. Linear Network Analysis (3)
417. System Theory (3)
418. Solid State Device Technology (3)
419. Solid State Devices (3)
421a,b,c,d. Electrical Engineering Problems (1-10)
423. Fundamentals of Industrial Electronics (3)
424. Fundamentals of Electrical Design (3)

425. Symmetrical Components (3)
428. Linear Control Systems (3)
429. Control System Design (3)
432. Microwave Methods and Analysis (3)
435. Engineering Analysis (3)
437. Engineering Applications of Complex Variables (3)
438. Antenna Engineering (3)
441. Active Circuits (3)
448. Linear Electronic Design (3)
449. Digital Electronic Design (3)
450. Network Analysis (3)
459. Introduction to Statistical Theory of Communications (3)
461. Fundamentals of Power System Stability (3)
470. Electronic Analog Computers (3)
471. Logical Design of Switching Systems (3)
472. Introduction to Digital Subsystems (3)
490. (Nuc.E. 490) Introduction to Plasma Theory (3)
491. Plasma Phenomena and Diagnostic Laboratory (3)
492. (Astro. 492) Space Astronomy and Introduction to Space Science (3)

514. Quantum Electronics (3) Quantization of electromagnetic fields; quantum statistics of attenuators and amplifiers; analysis of laser oscillators; Glauber P-representation; photon detection and coherence. Prerequisite: Phys. 561.

519. Semiconductor Devices (3) Characteristics and limitations of bipolar transistors, diodes, transit time and bulk-effect devices. Prerequisite: E.E. 419.

521. Advanced Electrical Engineering Problems (1-10)

523. Nonlinear Analysis (3) Transient and steady state analysis of nonlinear physical systems; phase plane analysis, iterative techniques, singular points, and subharmonics. Prerequisite: E.E. 435.

525. Symmetrical Components (3) Polyphase circuits and machines under unbalanced conditions of operation including effects of rotating machines upon distribution and transmission system performance; characteristics of phase converters and single-phase operation of polyphase systems. Prerequisite: E.E. 425.

527. Linear Control Systems (3) Continuous and discrete-time linear control systems; state variable models; analytical design for deterministic and random inputs; time-varying systems stability. Prerequisite: E.E. 428 or M.E. 455, E.E. 417.

528. Nonlinear Control and Stability (3) Design of nonlinear automatic control systems; phase-plane methods; describing functions; optimum switched systems; Liapunov stability; special topics in stability. Prerequisites: E.E. 428 or M.E. 455, E.E. 417.

529. Optimal Control (3) Variational methods in control system design; classical calculus of variations, dynamic programming, maximum principle; optimal digital control systems; state estimation. Prerequisite: E.E. 527.

530. Adaptive and Learning Systems (3) Adaptive and learning control systems; system identification; performance indices; gradient, stochastic approximation, controlled random search methods; introduction to pattern recognition. Prerequisite: E.E. 527.

532. Advanced Microwave Engineering (3) Theory of wave guides and discontinuities, resonant cavities, traveling wave oscillators and devices; interaction of fields with matter. Prerequisites: E.E. 432 and 411.

535. Engineering Analysis (3) Applications of mapping methods, series and integral representations to the solution of boundary value problems in electrical engineering. Prerequisite: E.E. 437.

536. Transform Methods in Linear Analysis (3) Analysis of linear systems by Laplace transform with emphasis on periodic nonsinusoidal forcing functions. Prerequisite: E.E. 435.

538. Electromagnetic Engineering (3) Electromagnetic fields using the Maxwell-Lorentz equations as applied to vector fields, special solutions to scattering, diffraction, and radiation problems. Prerequisite: E.E. 411.

539. Antenna Engineering (3) Boundary value problems of radiating structures, integral equation formulations, source excitation problems, reflector antennas. Prerequisites: E.E. 411, 438.

540. (Nuc.E. 540) Theory of Plasma Waves (3) Solutions of the Boltzmann equation; waves in bounded and unbounded plasmas; radiation and scattering from plasmas. Prerequisite: E.E. 490.

546. Field-Effect Devices (3) The physical background, characteristics and limitations of surface field-effect and junction field-effect devices and related structures. Prerequisite: E.E. 419.

547. Dielectric Devices (3) Applications of insulator physics and devices based on insulator properties. Prerequisite: E.E. 419.

548. Linear Integrated Circuits (3) Design of monolithic, thin-film and hybrid linear integrated circuits; D.C., video, tuned, r.f. and microwave applications. Emphasis on reliability. Prerequisites: E.E. 418, 448.

550. Network Synthesis (3) Positive real functions, realizability conditions, synthesis of driving point immittances, synthesis of two-terminal pair networks, transfer function synthesis. Prerequisites: E.E. 437, 450.

560. Statistical Theory of Communications (3) Generalized harmonic analysis; the application of correlation and convolution to the detection of signals in noise; various special topics. Prerequisite: E.E. 459 or Math. 409.

561. Information Theory (3) Mathematical measurement of information; information transfer in discrete systems; redundancy, efficiency, and channel capacity; encoding systems. Prerequisite: E.E. 459 or Math. 409.

562. Detection Theory (3) Detection decision theory, Bayes and Neyman-Pearson criteria, optimal receivers, classical estimation theory, signal-noise representations, optimum linear signal parameters estimation. Prerequisite: E.E. 560.

566. (Cmp.Sc. 566) Alegbraic Coding Theory (3) Polynomial rings, galois fields, linear codes, cyclic codes, BCH codes, finite projective geometry cyclic codes, convolution codes, graph theoretic codes. Prerequisite: Cmp.Sc. 450 or E.E. 561.

569. Simulation of Biomedical Systems (3) Simulation of biological and medical systems on analog and digital computers; direct electrical analogs; modeling techniques. Prerequisites: E.E. 470 or Cmp.Sc. 401 and Biol. 11.

570. Advanced Electronic Analog Computers (3) Advanced techniques of analog computation and simulation; machine and problem errors; nonlinear differential equations. Prerequisite: E.E. 470.

571. Digital Computers: Recent Developments and Advanced Logic (3) Advanced treatment of logical design; discussion of topics of current interest in the general area of digital computers. Prerequisite: E.E. 471.

572. Digital System Design (3) Complete digital system design including specification, internal organization, and realization. Discussion of interaction among digital systems and subsystems. Prerequisite: E.E. 472.

580. Radio Waves and the Ionosphere (3) The magneto-ionic theory of ionospheric wave propagation; ray-optical approximations; determination of ionization profiles; full wave solutions; nonlinear and coupling effects. Prerequisite: E.E. 62 or 438 or Phys. 557.

581. Constitution of the Ionosphere (3) Properties of neutral and ionized atmosphere above 60 km; photochemical processes; solar, meteoric perturbations of the ionosphere; large-scale movements in ionization.

591. (Nuc.E. 591) Plasma Theory (3) Advanced topics in kinetic theory, fluctuation theory, microinstability, and turbulence. Prerequisite: E.E. 590.

ELEMENTARY EDUCATION (EL ED)

Robert L. Lathrop
In Charge of Graduate Programs in Elementary Education
240 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Bixby, Bliesmer, Brewer, Corle, Heilman, McAulay, and Zafforoni.

Graduate Faculty: Associate Members Alessandro, Alfke, C. Cartwright, Shrigley, Suydam, and Trueblood.

The graduate programs provide advanced professional preparation for early childhood and elementary school teachers, curriculum specialists, elementary supervisory personnel, elementary school principals, and elementary teacher education personnel.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign languages.

For admission 18 credits in elementary education and teaching experience are required. Students with a 2.75 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.75 grade-point average may be made for students with special backgrounds, abilities, and interests.

The Master of Education degree in elementary education is offered also at the Capitol Campus. Specific requirements may be found in the *Capitol Campus Catalog*.

ELEMENTARY EDUCATION (EL ED)

426. Problems of Elementary School Arithmetic (2-3)
431. Contemporary Elementary School Mathematics Programs (2)
433. Teaching Social Studies in the Elementary Grades (2-3)
435. Field Natural History for Teachers (3)
436. Teaching of Conservation of Natural Resources in the Elementary School (3)
437. Teaching of Conservation of Natural Resources in the Elementary School (3)
438. Teaching Science in the Elementary School (1-3)
443. The Elementary School Reading Program (3)

449. Teaching Children's Literature (2-3)
453. Special Problems in the Teaching of Elementary School English (2-3)
467. School Programs for Young Children II (3)
479. Measurement of Achievement in the Elementary School (2-3)
485. Workshop in Selected Studies in Elementary Education (1-6)

511. Supervision of Student Teachers (3) A course in supervision for master teachers, department heads, and college teachers with supervisory responsibilities in teacher education. Prerequisites: teaching experience and 18 credits in education, including at least 5 in methods.

520. Internship in Elementary Education (3-6) Internship to take place in schools or educational situations where student is not regularly employed, under supervision of Graduate Faculty.

526. Applications of Research in the Teaching of Elementary School Mathematics (3) Research applications dealing with the study of curriculum, materials, evaluation, teaching, learning, and supervision of elementary school mathematics. Prerequisites: El.Ed. 426 and elementary teaching experience; Ed.Psy. 400.

533. Problems and Issues in Elementary School Social Studies (3) Historical-philosophical bases for the social studies: curriculum development, research findings and techniques, learning resources, and promising proposals. Prerequisites: El.Ed. 433 and elementary school teaching experience.

549. Children's Literature Related to Ethnic and Social Issues (3) Children's literature; K-12; study of literary symbolism, ethnic literature, and controversial issues; bibliotherapy, censorship, sex education through the trade book. Prerequisite: El.Ed. 449.

562. Problems of Elementary Education (2-3) Problems seminar for experienced educators. Prerequisite: 12 credits in education and psychology, including 6 in elementary education.

563. Seminar in Contemporary Issues in Elementary Education (1-3) Conferences and discussions designed to meet the needs of experienced teachers and principals in the field of elementary education. Prerequisites: 6 credits in elementary education and teaching experience.

564. Organization of the Elementary School Curriculum (2-3) Principles underlying curriculum construction. Primarily for elementary education majors. Prerequisite: El.Ed. 311 or teaching experience.

567. Issues and Trends in Early Childhood Education (3) Research, experimental programs and emerging trends in early childhood education; relationships between educational experiences and later intellectual and emotional development. Prerequisites: Ed.Psy. 400 and El.Ed. 467.

585. Workshop in Current Elementary School Problems (1-6) For experienced elementary school teachers: administrative, supervisory, and instructional problems involved in an emerging educational program. Prerequisite: 12 credits of graduate work in education.

588. Problems, Projects, and Area Studies in Elementary Education (1-6) Independent work in the study of topics in elementary education or the development of new curriculums, materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of the development head.

594. Seminar in Elementary Education (1-9) Conferences and discussions designed to meet the needs for special study of particular fields in education. Prerequisite: 12 credits of graduate work in elementary education.

ENGINEERING ACOUSTICS (E ACS)

JOHN C. JOHNSON
Acting Chairman of the Committee on Engineering Acoustics
Ordnance Research Laboratory, Applied Science Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Baker, Hayek, Johnson, Lawther, Michael, Pigott, Reethof, Rowlands, Sevik, Skudrzyk, Snowdon, and Tichy.

Graduate Faculty: Associate Members Farwell, Macaluso, Miller, Prout, and Sibul.

The aim of this intercollege program is to enable the student interested in acoustics to obtain an integrated program of courses covering the fundamentals of acoustical science and the biological, communications, and engineering applications of acoustics.

Programs are arranged through a selection of appropriate courses offered by the several departments of science, engineering, and arts, as well as those specifically in the area of engineering acoustics.

Areas of concentration include acoustic signal processing, architectural acoustics, noise and vibration, physical acoustics, speech and hearing, and underwater acoustics. Thesis research in the various areas may be conducted in relevant departments and in the Ordnance Research Laboratory.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by competence in the use of computer language as well as a reading knowledge of a foreign language.

Entering students should hold a bachelor's degree in physics, biology, engineering, architecture, mathematics, or speech and hearing, or in a closely related field; and they should have had at least one year of physics and mathematics including integral calculus. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

ENGINEERING ACOUSTICS (E ACS)

401. GENERAL ACOUSTICS (3)

500. SPECIAL PROBLEMS IN ACOUSTICS (1-6) Provides training in selected areas of acoustics by means of supervised investigations or studies. Prerequisite: Phys. 443.

501. ENGINEERING ACOUSTICS SEMINAR (1 per term) Recent developments and current research in engineering acoustics.

511. UNDERWATER SOUND PROPAGATION (3) Theoretical and empirical treatment of sound propagation in the ocean, including effects of the environment, characteristics of targets, and transducers.

512. SONAR ENGINEERING (4) Theoretical and empirical treatment of problems related to the use of underwater sound in target detection and ranging.

513. MODERN ACOUSTIC SIGNAL PROCESSING (4) Probability review, representation of signals, noise processes, optimum filtering, ambiguity functions, linear and nonlinear signal processing, application to sonar systems.

514. ELECTROACOUSTIC TRANSDUCERS (4) The theory, design, and calibration of passive, linear, reciprocal electroacoustic transducers for use in both air and water media. Prerequisite: Phys. 443.

515. Acoustics in Fluid Media (3) Wave propagation in stationary and moving fluids; acoustic radiation and scattering; standing waves in ducts and cavities. Prerequisites: E.Mch. 524A, Phys. 443.

ENGINEERING MECHANICS (E MCH)

Robert M. Haythornthwaite, *Head of the Department*
227 Hammond Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Davids, Hardenbergh, Hayek, Haythornthwaite, Hu, Jaunzemis, Kiusalaas, Mentzer, Neubert, Sharma, Vierck, and Zamrik.

Graduate Faculty: Associate Members Conway, Fonash, Llorens, and Queeney.

Graduate study is available in the following areas: (1) dynamics, including mechanics of rigid bodies, vibration, and stress waves; (2) mechanics of deformable bodies including elasticity, plasticity, viscoelasticity, and continuum mechanics; (3) mechanics of materials and structures including mechanical properties, plates and shells, and plastic analysis; (4) experimental mechanics including experimental stress analysis, photoelasticity, and experimental vibration.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

The entering student must hold a bachelor's degree in engineering or science and have satisfactorily completed undergraduate courses in mechanics. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

ENGINEERING MECHANICS (E MCH)

400.	Advanced Strength of Materials (3)	*Mr. Kiusalaas*
401.	Elements of Vibrations (3)	*Messrs. Davids and Vierck*
402.	Applied and Experimental Stress Analysis (3)	*Mr. Conway*
403.	Mechanics of the Solid State (4)	*Mr. Queeney*
404.	Research in Engineering Mechanics (1-6)	*Mr. Conway*
407.	Elements of Computer Methods in Engineering (3)	*Mr. Sharma*
408.	Elasticity and Engineering Applications (3)	*Messrs. Kiusalaas and Pytel*
409.	Advanced Mechanics (3)	*Mr. Hardenbergh*
410.	Mechanics of Space Flight (3)	*Mr. Hardenbergh*
412.	Experimental Methods in Vibrations (3)	*Mr. Neubert*
413.	Plastic Analysis of Structures (3)	*Mr. Haythornthwaite*
414.	Elements of Material Science (3)	*Mr. Kimmel*
421.	Continuum Mechanics (3)	*Messrs. Hayek and Pytel*
422.	Continuum Mechanics (3)	*Messrs. Hu and Jaunzemis*
446.	Mechanics of Viscoelastic Materials (3)	*Mr. Sharma*

500. Advanced Mechanics of Materials (3-6) Strain energy methods; special problems in bending and torsion; curved bars, beams on elastic foundations; thick-walled cylinders, shrink-fit assemblies, and rotating disc; thin-walled pressure vessels; bending of thin plates; buckling of bars and plates. Prerequisite: E.Mch. 13.
Messrs. Kiusalaas and Zamrik

506. Experimental Stress Analysis (3) Experimental methods of stress determination including photoelasticity, stress coat and electric strain gauge techniques; stress analogies; strain rosettes for combined stress determinations. Prerequisite: E.Mch. 408 or 507. *Mr. Conway*

507. Theory of Elasticity and Applications (3) Equations of equilibrium and compatibility; stresses and strains in beams, curved members, rotating discs, thick cylinders, torsion and structural members. Prerequisite: E.Mch. 13. *Mr. Sharma*

508. Theory of Elastic Stability and Applications (3) Buckling of slender and short members; buckling of I-beams; stability of thin-walled constructions; thin-walled cylinders subjected to external pressures; applications to structural parts including aircraft members. Prerequisites: E.Mch. 12, 13. *Mr. Kiusalaas*

509. Theory of Plates and Shells (3) Bending and buckling of plates; elastic foundations; deformation of shells, multilayer shells, stress and stability analysis, weight optimization, application problems. Prerequisite: E.Mch. 13. *Mr. Kiusalaas*

514. Engineering Mechanics Seminar (1 per term) Current literature and special problems in engineering mechanics. *Staff*

516. Mathematical Theory of Elasticity (3) Fundamental equations and problems of elasticity theory; uniqueness theorems and variational principles; methods of stress functions and displacement potential; applications. Prerequisite: E.Mch. 540. *Mr. Jaunzemis*

520. Advanced Dynamics (3) Dynamics of a particle and of rigid bodies: Newtonian equations in moving coordinate systems; Lagrange's and Hamilton's equations of motion; special problems in vibrations and dynamics. Prerequisites: E.Mch. 12, Math. 72 or 431. *Mr. Kiusalaas*

521. Stress Waves in Solids (3) Theoretical fundamentals, classic experiments; recent advances, including scabbing applications, plastic waves, penetration mechanics, impact, and numerical methods. Prerequisites: E.Mch. 12; Math. 405 or E.Mch. 524. *Mr. Davids*

522. Theory of Vibrations (3) Mathematical theory of vibrating systems; damping phenomena; forced vibrations; analogy between mechanical and electrical vibrations; transverse and torsional oscillation of shafts; vibration of strings, beams, membranes, and plates. Prerequisites: E.Mch. 13, Math. 72 or 431. *Messrs. Vierck and Neubert*

523. Computer Methods in Engineering Analysis (3) Finite elements, finite differences, and matrix methods applied to dynamics, elasticity, wave propagation, heat conduction, structural analysis, and fluid flow. Prerequisites: Cmp.Sc. 401, Math. 72. *Mr. Davids*

524. Mathematical Methods in Engineering (3 per unit) Prerequisite: A.M. 451 or E.E. 435 or M.E. 452. *Mr. Hayek*

Unit A (3) Basic tools, including Fourier, Legendre, and other orthogonal series, special functions, Laplace transforms. Applications in mechanics and other fields. Prerequisite: Math. 73.

Unit B (3) Solution techniques for boundary-value problems in curvilinear coordinates, integral transforms, Green's functions, potentials, applications to diffusion, vibration, wave-propagation. Prerequisite: E.Mch. 524A or Math. 431.

525. Vibration and Shock in Damped Mechanical Systems (3) Rubberlike materials; vibration isolation; structural impedance; wave propagation; multi-force excitation of beams; Timoshenko beams; transients; shock spectra; damage; nonlinear response. Prerequisite: E.Mch. 401 or 522. *Mr. Snowden*

526. Nonlinear Mechanics (3) Integral curves, singular points, self-sustained oscillations, stability problems, Hill's and Van der Pol's equation, mechanical and electrical application. Prerequisite: E.Mch. 522. *Mr. Neubert*

527. Structural Dynamics (3) Dynamic behavior of structural systems; normal modes; input spectra; finite element representation of frameworks, plates, and shells; impedance; elastic-plastic response. Prerequisites: E.Mch. 12, 13. *Mr. Neubert*

528. Experimental Methods in Vibrations (3) Investigation of one or more degrees of freedom, free and forced mechanical vibrations, vibration properties of materials, nondestructive testing. Prerequisite: E.Mch. 401 or 522. *Mr. Neubert*

530. Solid State Mechanics (3) Relation between solid state physics and mechanics; mechanical properties for static, fatigue, creep, and impact conditions; high temperature properties; applications. Prerequisite: E.Mch. 14. *Messrs. Hu and Zamrik*

531. Theory of Plasticity and Applications (3) Yield condition; plastic stress-strain relations; theory of slip-line fields; applications to bending, torsion, axially symmetric bodies, metal processing. Prerequisite: E.Mch. 507. *Mr. Hu*

533. Determination of Mechanical Properties (3) Experimental methods for determining hardness, elastic constants, creep behavior, fatigue strength, plastic flow, and dynamic properties of metals. Prerequisite: E.Mch. 14 or 530. *Mr. Hu*

534. Photoelasticity (3) Analysis of polariscopes; isoclinics, isochromatics, and stress trajectories; two- and three-dimensional photoelastic methods; determination of principal stresses; model preparation. Prerequisite: E.Mch. 408 or 507. *Mr. Conway*

535. (Metal. 535) Crystal Defects and Mechanical Response (3) Mechanical responses of crystalline solids containing point, line, and interfacial defects; elastic and plastic responses. Prerequisite: Metal. 514 or E.Mch. 414. *Mr. Queeney*

540. Introduction to Continuum Mechanics (3) Algebra and analysis of tensors; balance equations of classical physics; the linear theories of continuum mechanics. Prerequisite: E.Mch. 421. *Mr. Jaunzemis*

541. Nonlinear Theories of Continuum Mechanics (3) The general theory of constitutive equations; finite deformations and elasticity; flow and fluidity; viscoelasticity, modern topics. Prerequisite: E.Mch. 540. *Mr. Jaunzemis*

546. Theory of Viscoelasticity and Applications (3) Linear and nonlinear viscoelastic theories; generalized isotropic and anisotropic viscoelastic stress-strain relations. Prerequisite: E.Mch. 507. *Mr. Sharma*

550. Studies in Engineering Mechanics (1-6) Studies in any field of engineering mechanics.

570. Random Vibrations in Structural Mechanics (3) Probability theory applied to random vibrations of linear and nonlinear systems; excitation by ground motion, turbulence, and noise; acoustic damping. Prerequisite: Aersp. 411 or E.Mch. 401 or 522. *Mr. Neubert*

ENGINEERING SCIENCE (E SC)

John B. Nesbitt
Chairman of the Engineering Graduate Committee for Off-Campus Programs
116 Sackett Building

Degree Conferred: M.Eng.

A program leading to the degree of Master of Engineering with a major in engineering science is offered at the Behrend and King of Prussia Graduate Centers and at the Capitol Campus near Harrisburg. Details of the program may be obtained by writing directly to these locations. Addresses are given in the front of this bulletin.

The program is designed to provide a broad, advanced education in the engineering sciences with some specialization permitted in the area of a student's major interest. It is offered specifically to permit practicing engineers to pursue advanced studies through evening classes while in full-time employment in industry in the area. Courses offered for the program are all established and controlled by the resident departments at the University Park Campus.

The credit requirements in this major will be satisfied by an appropriate combination of core courses and elective courses. The core courses include offerings in mathematics and in several branches of engineering which have been selected because of their general character and breadth of applicability to all fields of engineering.

A minimum of 33 credits is required of which at least 12 must be at the 500 level. A scholarly written report is also required. Three of the above credits may be applied to this report.

Students may be admitted to the program from a wide variety of disciplines. Students applying for admission are expected to have completed the following core of previous student experience: (1) physics through atomic physics, (2) mathematics through differential equations, (3) one course in engineering thermodynamics, (4) one course in electrical circuits, and (5) basic courses in engineering statics and dynamics. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Further details regarding admission requirements are available from the directors of the graduate campuses offering the program.

ENGLISH (ENGL)

David H. Stewart, *Head of the Department*
117 Burrowes Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty: Senior Members Austin, Bayard, Condee, Frank, Goldberg, Jewkes, Lewis, Meserole, Price, Reed, Rosenberg, Rubin, Sams, Stewart, Weintraub, West, and Young.

Graduate Faculty: Associate Members Begnal, Borklund, Crane, Fitzgerald, Gidez, Grecco, Lougy, Mann, Rogers, Secor, and Walden.

A student may specialize in English literature, American literature, philology, or rhetoric. It is preferred that an entering student present 24 credits in English, but 18 credits in English exclusive of survey and freshman courses will be accepted. If the student does not present 18 credits in English, he must make up the deficiency early in his graduate work. A thesis is required of all M.A. candidates in this major.

The communication and foreign language requirement for the Ph.D. degree may be met by successful performance in any one of the following options: (1) critical and scholarly competence in one area of the literature of a foreign language; (2) reading, writing, and speaking knowledge of one foreign language; (3) reading knowledge of two foreign languages; or (4) reading knowledge of one foreign lan-

guage and demonstrated competence (normally by successful course work) in a technique such as computer science, statistics, etc., where relevant to the student's research interest.

Students with a 3.20 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.20 grade-point average may be made for students with special backgrounds, abilities, and interests.

ENGLISH (ENGL)

406. History of the English Language (3) *Messrs. Buckalew and Shedd*
407. History of the English Language for Teachers (3) *Messrs. Buckalew and Shedd*
408. Advanced College Grammar (3)
411. Problems of Style (3)
412. The Writing of Fiction (3-6) *Messrs. Klass, Rogers, Rubinstein, and West*
413. Verse Writing (3-6) *Mr. Haag*
414. Biographical Writing (3) *Mr. Weintraub*
415. Nonfiction Writing (3) *Mr. Klass*
418. Advanced Technical Writing and Editing (3-6) *Messrs. Damerst and Houp*
422. Masters of British Literature (3-6)
423. History of British Literature (3) *Mr. Arnold*
424. Movements in British Literature (3)
432. Masters of American Literature (3-6) *Staff*
433. History of American Literature (3) *Mr. Gidez*
434. Movements in American Literature (3-6) *Staff*
435. The American Short Story (3)
437. American Poetry (3) *Mr. Rubin*
438. American Drama (3) *Mr. Grecco*
441. Poetry and Prose of the Early Seventeenth Century (3) *Mr. Arnold*
442. Poetry and Prose of the Late Seventeenth Century (3)
443. Jacobean and Caroline Drama (3) *Messrs. Arnold and Jewkes*
444. Shakespeare: the Genres (3) *Messrs. Arnold, Jewkes, Moore, Price, and Reed*
445. Chaucer (3) *Messrs. Frank and Shedd*
446. Milton (3) *Messrs. Christopher, Moore, Condee, and McAdams*
447. The Elizabethan Renaissance (3) *Mr. Reed*
448. English Drama Before Shakespeare (3) *Mr. Jewkes*
449. Studies in Shakespeare (3) *Messrs. Arnold, Jewkes, Moore, Price, and Reed*
450. Readings in English (1-6)
451. Poetry and Prose of the Early Eighteenth Century (3) *Mr. Fitzgerald*
452. Poetry and Prose of the Late Eighteenth Century (3) *Mr. Buck*
455. The Novel in England to Jane Austen (3) *Mr. Fitzgerald*
458. The Drama from Dryden to Sheridan (3) *Mr. Rogers*
461. British Nonfictional Prose of the Nineteenth Century (3) *Miss Austin*
462. Wordsworth and Coleridge (3) *Mr. Cramer*
463. Byron, Shelley, and Keats (3) *Miss Austin*
465. Victorian Novel (3) *Miss Austin and Mr. Lougy*
466. The American Novel to 1900 (3) *Mr. Gidez*
467. Victorian Poetry (3) *Messrs. Cramer and Lougy*
470. Literature of the British Commonwealth (3)
475. Modern British Fiction (3) *Messrs. Maxwell and West*
476. The American Novel Since 1900 (3) *Mr. Young*
477. British and American Poetry of the Twentieth Century (3) *Mrs. Rodgers and Mr. Haag*

478. British and Irish Drama Since 1890 (3) *Mr. Weintraub*

481. History of English Literary Criticism (3) *Messrs. Borklund and Gidez*

488. (C.Lit. 488) Modern Continental Drama (3) *Messrs. Christopher and Grecco*

490. Rhetorical Theory and Practice (3) *Messrs. Holahan and Rubinstein*

491. Literature for Teachers in Secondary Schools (3)

*498. English Institute (6-12)

501. Materials and Methods of Research (4) Materials and techniques of research in English and American literary history; form and content of theses. Required of all graduate students with an English major. *Mr. Meserole*

520. The Middle English Romance (3) A detailed study of the Middle English metrical romance in terms of its milieu and its genre in the West.

521. Old English Language (3) An introduction to the main features of the Old English language; readings in simple Old English prose and poetry. *Mr. Buckalew*

522. Beowulf (3) Reading and critical analysis. Prerequisite: Engl. 521.

523. Wordsworth and Coleridge (3) Major and some minor works; the pertinent criticism and scholarship; aspects of the period. *Mr. Cramer*

524. Byron and Shelley (3) Major and some minor works; the pertinent criticism and scholarship; aspects of the period. *Miss Austin*

525. Blake and Keats (3) Major and some minor works; the pertinent criticism and scholarship; aspects of the period. *Miss Austin*

526. Tennyson and Browning (3) *Mr. Cramer*

536. Henry James (3) The development of James as critic, novelist, and short story writer. *Mr. Borklund*

537. Robinson and Frost (3) The art and thought of two American poets who link the traditions of the nineteenth and twentieth centuries.

540. Studies in Elizabethan Prose and Poetry (3-6) *Messrs. Price and Reed*

541. Medieval Studies (3-6) Special problems in medieval English literature. *Messrs. Frank and Rosenberg*

542. Middle English Literature (3) Introduction to Middle English and its dialects; study of the literature of the period exclusive of Chaucer.

543. Studies in Early Seventeenth Century Literature (3-6) Major poets and prose writers from 1600 to 1660. *Mr. Condee*

544. Restoration Literature (3) Selected studies of writers in England between 1650 and 1700. *Mr. Fitzgerald*

545. Chaucer (3-6) Critical study of the *Canterbury Tales* or *Troilus and Criseyde* and minor poems. *Messrs. Frank and Rosenberg*

546. Milton (3) The poetry and prose of John Milton. *Mr. Condee*

548. Elizabethan and Jacobean Drama (3-6) English drama from 1558 to 1642 exclusive of Shakespeare. *Mr. Jewkes*

* A maximum of 6 credits in one summer.

549. Shakespeare (3-6) Special problems of sources, chronology, text, characterization, and motivation in the drama. *Messrs. Jewkes, Price, and Reed*

552. Swift and Pope (3) *Mr. Sams*

553. The Age of Johnson (3) The work of Johnson and his circle. *Mr. Fitzgerald*

554. Studies in Early American Literature (3) *Mr. Meserole*

555. The Puritans (3) Critical studies of the principal works of English and American Puritans. *Mr. Meserole*

556. Eighteenth Century British Fiction (3) *Messrs. Fitzgerald and Sams*

557. Early Eighteenth Century British Literature (3) Prose and poetry in the reign of Queen Anne, with special attention to periodical publications. *Mr. Sams*

560. American Romanticism (3) The Romantic movement in American literature of the mid-nineteenth century.

561. Studies in the Romantic Movement (3-6) *Miss Austin*

562. Studies in the Literature of Victorian England (3-6) *Miss Austin, Messrs. Cramer and Weintraub*

564. Studies in Nineteenth Century American Literature (3) The major figures treated will vary from year to year. *Messrs. Rubin and Gidez*

573. Studies in Twentieth Century British Literature (3-6) Major writers and literary movements. *Messrs. Weintraub and West*

574. Studies in Twentieth Century American Literature (3-6) Major writers and literary movements.

575. James Joyce (3-6) Alternate terms: *Ulysses* and *Finnegans Wake.* Knowledge of *Dubliners* and *A Portrait of the Artist* is assumed. *Mr. Begnal*

576. Hemingway and Faulkner (3) The major works. *Mr. Young*

578. Shaw (3) The plays, prose writings, and literary influence of G.B.S. *Mr. Weintraub*

579. T. S. Eliot (3) Major works in poetry, criticism, and drama; pertinent scholarship and criticism. *Mr. Lewis*

581. Contemporary Literary Criticism (3) *Messrs. Sams and Borklund*

582. Hawthorne and Melville (3) Detailed study of the major works of both authors and of the relationship between the two men. *Messrs. Young and Gidez*

583. Emerson and Thoreau (3) The significant prose and poetry of the chief American transcendentalists.

584. Whitman and Dickinson (3) The major texts, with special emphasis on background and language. *Mr. Rubin*

585. Twain and Howells (3) The principal works, the relationship between the two men, and their place in American literature. *Mr. Lewis*

586. Readings in Literature (1-12) Programs of readings designed to meet specific needs of individual students.

587. Franklin and Edwards (3) Studies in the lives, works, and milieu. *Mr. Meserole*

588. Studies in American Fiction (3-6) *Mr. Gidez*

589. Studies in American Poetry (3-6) *Messrs. Rubin and Hansen*

592. Studies in American Literary Myth (3) An introduction to an interpretive, interdisciplinary study of some representative themes in American literature and culture. *Mr. Young*

593. (C.Lit. 593) Anglo-American Folk Song (3) Survey of relevant literary and ethnological scholarship and field work, European and American, from the early sixteenth century to the present. *Mr. Bayard*

595. Studies in British Fiction (3-6) *Mr. Weintraub*

ENTOMOLOGY (ENT)

Beckford F. Coon, *Head of the Department*
102 Patterson Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members Asquith, Benton, Coon, Kim, Mumma, Rutschky, Smyth, Snetsinger, and Yendol.

Graduate Faculty: Associate Members Ercegovich, Hower, and Smilowitz.

A student majoring in entomology may specialize in various areas of economic entomology and in forest entomology, apiculture, insect resistance in plants, arachnology, medical or veterinary entomology, biological control, insect pathology, insect transmission of plant pathogens, ecology, morphology, embryology, taxonomy, physiology, insect behavior, or chemistry of pesticides.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by one foreign language and proficiency in English.

For admission a student is required to have 24 credits in entomology and related biological and physical sciences. Chemistry through organic, physics, mathematics, and statistics are advantageous. A limited deficiency may be made up, without degree credit, while pursuing graduate work.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

ENTOMOLOGY (ENT)

401. Medical and Veterinary Entomology (3) *Mr. Kim*
403. (Biol. 403) Systematics (3) *Mr. Kim*
409. Insect Biology and Management (3) *Mr. Rutschky*
412. Field Entomology (3) *Mr. Rutschky*
414. Insect Morphology and Phylogeny (3) *Messrs. Rutschky and Kim*
415. Insect Physiology and Biochemistry (3) *Messrs. Smyth and Mumma*
416. Insect Ecology and Control (3) *Messrs. Cameron and Hower*
418. Forest Entomology (3)
431. Special Problems (1-6)
435. Arachnology (3) *Mr. Snetsinger*

515. Insect Morphology and Systematics (1-3) Current theories, controversies and advanced techniques in comparative morphology, histology, embryonic and postembryonic development, taxonomy and systematics of insects. Winter term.

516. Insect Physiology and Biochemistry (1-3) Selected topics in insect function and metabolism. Spring term.

517. Insect Ecology and Behavior (1-3) Selected aspects of the biotic and abiotic interactions of insects. Fall term.

518. Pest Management (1-3) Current concepts and controversies in modern agricultural and urban pest management practice. Winter term.

531. Insect Toxicology (2) General principles of toxicology and survey of the actions of substances toxic to insects. Fall term, odd years.

532. Insect Behavior (2) Orientation reflexes, learning, communication, and social behavior; physiological bases, ecological and evolutionary implications. Summer term, odd years.

535. Biological Control (3) Practical and theoretical aspects of arthropod control by entomophagous insects and the place of biocontrol in integrated control programs. Spring term, even years. *Messrs. Yendol and Smilowitz*

536. Insect Pathology (3) Diseases of arthropods and some aspects of microbial control of insects. Prerequisite: Micrb. 1. Spring term, odd years.

ENVIRONMENTAL POLLUTION CONTROL (EPC)

William J. Moroz
In Charge of Graduate Programs in Environmental Pollution Control
226 Chemical Engineering Building II

Degrees Conferred: M.S., M.Eng., M.E.P.C

Graduate Faculty: Senior Members Aplan, Eagleton, Heicklen, Hunt, Langmuir, Moroz, Nesbitt, and Watrous.

This intercollege program deals with the various aspects of the control of air and water pollution and the disposal of solid wastes. Graduate instruction is under the direction of an interdisciplinary faculty committee and the departments participating in the program. The faculty consists of the committee members listed above and a larger group of graduate faculty members with a teaching and/or research interest in the area of environmental pollution control.

Students are required to pass 9 credits of core courses: C.E. 472, Water Pollution Control; C.E. 476, Solid Waste Management; and M.E. 470, Introduction to Air Pollution Control. In addition, they must select at least 21 of their total credits from a recommended course list and schedule the environmental pollution control seminars (590) for three terms. A thesis is optional. If the option to prepare a thesis is selected, the topic must be in the area of environmental pollution control and at least 6 credits of research must be taken in the department in which the student is affiliated.

Admission to the program will be granted upon recommendation of the academic department in which the student plans to follow his studies and the Environmental Pollution Control Program Faculty Committee. Students wih a 2.50 junior-senior average and with appropriate backgrounds in mathematics and science will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

EXTENSION EDUCATION (EXTED)

WILLIAM M. SMITH, JR.
Chairman of the Committee on Extension Education
105 Weaver Building

Degrees Conferred: M.Agr., M.Ed.

This program is designed primarily to meet the needs of professional teachers in various extension and adult education positions. The purpose is to train individuals to develop attitudes, understandings, and competences which enable them to become more effective professional workers. Options have been developed for the College of Agriculture. Additional options will be offered as they are developed by other colleges.

For either degree a minimum of 30 credits is required, in addition to a professional paper. These credits should be distributed as follows: 12 credits in extension core courses, 6 in communication and/or education, and 12 in two areas of agriculture and/or home economics.

Admission requirements include a strong background in agriculture or home economics and a minimum of 12 credits in the social sciences. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

FOOD SCIENCE (FD SC)

DONALD V. JOSEPHSON
Chairman of the Division of Food Science and Industry
111 Borland Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Day, Dimick, Josephson, Keeney, MacNeil, McArdle, McCarthy, Patton, Sink, Thompson, and Watrous.

Graduate Faculty: Associate Members Beelman, Kroger, Kuhn, and Ziegler.

Opportunities are available for study in the fields of dairy products, meats, fruits and vegetables, and poultry products. Special emphasis can be devoted to food chemistry, microbiology, quality control, flavor control and acceptance, rheology, processing, packaging, and distribution.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Prerequisite to graduate work is the completion of an undergraduate degree in food science, biochemistry, microbiology, or another related area. The undergraduate program must include calculus, organic chemistry, microbiology, and general physics. Students may be admitted with deficiencies but are required to make them up without degree credit. Students who present a 2.50 junior-senior average will be considered for admission to the program subject to the limitations of the physical facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

FOOD SCIENCE (FD SC)

400. EFFECTS OF PROCESSING ON FOODS (3)
402. THE THERMAL PROCESS (1)

403. Sanitation and Quality Control (3)
410. Chemical Methods of Food Analysis (4)
421. Technical Control Problems (1-6)

505. Concepts of Product Development (3) Interrelationships of processing principles and chemical and physical properties in the development of new and improved food products.

507. Food Quality, Food Standards, and Consumer Protection (2) Problems of the food industry relating to contamination and quality of food products.

510. Seminar in Food Science (1-6)

520. Problems in Food Science (1-9) Special problems in dairy, horticultural, meat, poultry, and other food products.

522. Research Procedures in Food Science (3) Research problems and methods in food science with major emphasis on food chemistry.

In addition to the courses listed above, the following courses are available in food science; their descriptions may be found under the offerings of the cooperating departments: A.I. 421, 431, 502; Ag.E. 412, 413, 414, 423, 503; D.Sc. 427, 521; Hort. 528; Micrb. 414; Pty.Sc. 504.

FOREST RESOURCES (FOR R)

Wilber W. Ward
Director of the School of Forest Resources
101 Ferguson Building

Degrees Conferred: Ph.D., M.S., M.F.

Graduate Faculty: Senior Members Borden, Fletcher, George, Gerhold, Hutnik, Murphey, Shipman, Sopper, and Ward.

Graduate Faculty: Associate Members Beall, DeWalle, Dress, Lindzey, and Turner.

The graduate programs include two areas of technological inquiry, forest resource management and forest products; and two areas of scientific inquiry, forest science and wood science.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by a demonstrated competence in one foreign language equivalent to passing three college-level courses.

The technological area of forest resource management, which is concerned with planning and operation of the forest land complex, may include specialization in timber management, wildlife management, watershed management, forest recreation, or a combination of all of these land use concepts within the framework of multiple objectives. An undergraduate degree in forest management or a similar program emphasizing biological science, economics, and mathematics provides the preparation necessary for these specializations.

The technological area of forest products is concerned with the application of wood technology to the forest products industries with possible specialization in industrial management, quality control, and marketing. An undergraduate degree in wood utilization or a similar program emphasizing mathematics and basic engineering courses is prerequisite.

The forest science area is concerned with those disciplines fundamental to forest management, including forest ecology, wildlife ecology, forest economics, forest

entomology, forest genetics, forest hydrology, forest pathology, forest soils, tree physiology, mensuration, and silviculture. An undergraduate degree in forestry or a comparable degree emphasizing mathematics and biological, chemical, and physical sciences is prerequisite.

The wood science area is concerned with the fundamentals of the structural, physical, mechanical, and chemical properties of wood. The student may specialize in wood anatomy, wood moisture relations, wood chemistry, wood adhesion, wood engineering, and pathological and entomological considerations of wood products. An undergraduate degree in wood utilization or its equivalent in mathematics and biological and physical sciences is prerequisite.

For admission a student should present at least a 2.50 all-university average and 9 credits of basic biology; 12 credits of calculus, statistics, or computer science; 12 credits of chemistry and physics; 12 credits of communications; 12 credits of economics and social sciences, or humanities; and 18 credits in the professional fields served by the School of Forest Resources. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. All applicants should submit a brief statement describing their interests, goals, and special qualifications related to their proposed graduate studies.

FORESTRY (FOR)

403. Dendrology (3)
410. Forest Resources Seminar (1)
416. Forest Recreation (3)
421. Silviculture (3)
427. Forest Range Management (3)
440. Forest Economics and Finance (3)
450. Advanced Mensuration (3)
455. Aerial Photos in Forestry (3)
466. Forest Resource Management (3)
480. Policy and Administration (3)
497. Problems in Forestry (1-6 per term)

508. Advanced Forest Ecology (3) Organization, development, and classification of forest communities. Prerequisite: For. 308.

509. Wildlife Habitat Management (3) Management of forest associations for maintenance and development of wildlife. Prerequisite: For. 508 or Biol. 516.

512. Forest Genetics (3) Theoretical and practical application of genetics to forestry; experiments in genetic variation, breeding, progeny testing, and vegetative propagation of trees. Prerequisite: Biol. 22.

517. Forest Microclimatology (3) Forest microclimatology quantitative treatment of climate near the ground, with special reference to the role of forests and terrain. Prerequisite: Phys. 202.

519. Forest Hydrology (3) Influence of forest cover on the disposition of precipitation and the application of hydrologic principles and techniques to forest watersheds. Prerequisites: For. 308, C.E. 51.

521. Advanced Silviculture (3) Specific silvicultural practices for the establishment and manipulation of forest stands with respect to recent developments and research needs. Prerequisite: For. 421.

525. Forest Land Use Alternatives (3) Recognition and analysis of various compatible and conflicting uses of forest land as a component of rural land. Prerequisites: For. 466, Ag.Ec. 421 or Geog. 405, 3 credits in statistics.

550. Design and Analysis of Experiments (3) Specialized techniques involved in the design and analysis of complex forestry research problems. Prerequisite: For. 450.

560. Timber Management (3) Technical methods in the organization and control of the forest property for timber production.

575. Applications of Forest Economics and Finance (3) Survey of situations in forestry where business problems and particular circumstances of production, value, and costs are currently significant. Prerequisite: For. 440.

WOOD SCIENCE (W S)

411. Physical Properties of Wood (3)
412. Mechanical Properties of Wood (3)
413. Chemical Properties of Wood (3)
414. Pulp and Fiber Technology (3)
420. Processing and Machining of Wood (2)
421. Adhesives and Finishes for Wood Products (2)
422. Seasoning and Preservation (2)
430. Forest Products Manufacturing Systems and Standards (3)
469. Problems in Wood Science (1-6)
491. Logging and Lumbering (3)
495. Forest Products Production Management (3)
497. Small Sawmills (3)

502. Wood Fibers (3) Identification and physical and chemical characteristics of wood fibers used for pulp, either for paper or as a source of cellulose; pulping quality, fiber measurements.

511. Wood-Fluid Relationships (3) Treatment of adsorption equations, thermodynamics, and diffusion through wood. Prerequisite: W.S. 337.

513. Wood Chemistry (3) Treatment of the chemical components of wood, their distribution and reactions. Prerequisite: W.S. 413.

531. Mechanical Behavior of Wood (3) Time-dependent properties, theory of failure, rheologic properties, and theory of the mechanical behavior of wood and structural composites.

532. Theory of Adhesion (3) Theory of adhesion as it pertains to bonding of wood, paper-based laminates, fibers, and bonding of wood to dissimilar materials.

595. Forest Products Industrial Operations Analysis (3) Applications of operations research methods in the forest products industry; mathematical programming, simulation, waiting line problems, sequencing. Prerequisite: W.S. 495.

FRENCH (FR)

Richard L. Frautschi, *Head of the Department*
S-404 Burrowes Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Belasco, Brault, Chapman, Frautschi, Hyslop, and LeSage.

Graduate Faculty: Associate Member Knight.

A student may follow a graduate program in French literature and in descriptive and historical linguistics with a minor in a related field. M.A. candidates may submit either a thesis or a term paper. If the latter is chosen, 6 additional credits in 500-level courses in the major program must be scheduled. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages or by a comprehensive knowledge of one.

The minimum requirement for admission to an advanced degree program will normally be 27 credits of post-intermediate work in language and literature. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

FRENCH (FR)

417. French Phonology (3)
418. French Morphology and Syntax (3)
422. Old French Literature (3)
426. French Literature of the Renaissance (3)
430. Contemporary France (3)
435-436. Seventeenth Century French Literature (3 each)
445. The French Novel of the Eighteenth Century (3)
446. French Drama of the Eighteenth Century (3)
451-452. Nineteenth Century French Literature (3 each)
460. French Prose of the Twentieth Century (3)
461. French Poetry and Drama of the Twentieth Century (3)
470. Advanced Composition and Conversation (3)
471. Advanced Stylistics (3)
480. The Teaching of French (4)
491. Problems in French Literature (3-6)
499. Foreign Study in French (3)

*1G. Elementary French for Graduate Students (3) Designed for students preparing to satisfy language requirements for advanced degrees.

*2G. Elementary French for Graduate Students (3) Continuation of Fr. 1G with reading practice.

500. An Introduction to Old French (3) Analysis of the phonology, morphology, and syntax of the Old French language based on early literary monuments.

503. French Phonology (3) Articulatory and acoustic correlates of distinctive features; synchronic dialectology; phonology in generative grammar.

504. French Morphology and Syntax (3) Principles of segmentation and decomposition; tagmemics and transformation theory; morphophonemics.

505. Semantic Theory of the French Language (3) The goals of semantic description; systematic interrelation of semantic generalizations; empirical and methodological constraints.

516. The Song of Roland (3) Seminar in the Old French *Chanson de Roland,* with emphasis on the problems of textual criticism and literary analysis.

517. Villon (3) The poetry of Villon with reference to the cultural and social context of the late medieval period.

* No graduate credit is given for this course.

518. Medieval French Drama (3) The development of French drama from its liturgical origins to the flourishing comic theater of the late Middle Ages.

526. Rabelais (3) Seminar in works of François Rabelais, notably Book I (Pantagruel) and Book II (Gargantua), with emphasis on comic devices and narrative technique.

527. French Renaissance Poetry (3-6) Evaluation of French poetry from Marot through the Pléiade; emphasis on Ronsard and DuBellay.

528. Montaigne (3) Genesis and evolution of Montaigne's creation of the personal essay; influence of the *Essais* in seventeenth, eighteenth century French literature.

533. Seventeenth Century Prose and Poetry (3) The development of Classicism; its apogee and decline as seen in the works of major prose writers and poets.

534. Moliere (3) The literary achievement of Molière, the comic playwright, director, actor, and founder of the Comédie Française.

535. Seventeenth Century French Tragedy (3) The development and triumph of tragedy as a literary genre with special emphasis on the achievement of Corneille and Racine.

536. La Fontaine (3) The literary artistry of La Fontaine with special emphasis on his contribution as a fabulist.

540. Voltaire (3) The artistic and philosophical evolution of Voltaire as seen in the tragedy, the philosophical tale, and poetry.

541. Rousseau (3) Rousseau's rationalistic critique of civilization; his sentimental rehabilitation of the individual, family, state; Rousseau precursor of Romanticism.

542. Diderot and the Encyclopedists (3) The literary *philosophe* in the Age of Enlightenment with special emphasis on Diderot and his collaborators on the *Encyclopédie.*

561. French Romanticism (3) The Romantic movement in French literature with emphasis upon its major exponents in prose and poetry.

563. French Realism (3) The Realistic movement in French literature with emphasis upon its major exponents in prose and poetry.

565. The Nineteenth Century French Novel (3) The development of the novel in the nineteenth century with emphasis on Constant, Balzac, Stendhal, Flaubert, and Zola.

567. Twentieth Century French Theatre (3) Evolution of the French theatre form the plays of the *belle époque* to the avant-garde works of today.

568. Baudelaire (3) A study of his poetry and his criticism.

569. Masters of Twentieth Century French Literature (3-6) Major literary figures of contemporary French literature.

571. French Literary Criticism from Sainte-Beuve to Present (3) Evolution of French literary criticism from Sainte-Beuve, the "father" of modern literary criticism, to contemporary critics.

580. Seminar in French Literature (3-12) Lectures on methods of research. Students will pursue common and individual investigations in fields selected after consultation with the instructor.

581. Theory and Techniques of Teaching French (1-3)

586. Symbolism (3) The anti-positivistic tradition in nineteenth-century French literature dealing with the Symbolist School; its antecedents and its subsequent ramifications.

587. Research Techniques and Bibliography in French Language and Literature (1-3)

595. Analysis of French Civilization (3-6) French cultural aspects, other than language and literature, conducted in French with the collaboration of specialists outside the French department.

FUEL SCIENCE (F SC)

Howard B. Palmer
In Charge of Graduate Programs in Fuel Science
320 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Austin, Essenhigh, Given, Palmer, Polansky, Vastola, and Walker.

Graduate Faculty: Associate Member Becker.

This program is one of the options in which a graduate student in the Department of Material Sciences can receive an advanced degree.

Research facilities, well instrumented, are available for the study of high temperature gas reactions by shock-tube and other techniques, electrochemical kinetics of fuel cell and battery systems, reactions in plasmas and flames, physics and chemistry of carbons and graphites, fundamental processes in the industrial combustion of gaseous, liquid, and solid fuels, mass spectrometric investigation of the structure of solids, comminution of brittle materials, and the organic geochemistry of plant-derived sediments. Students can plan a wide variety of programs of study, to suit individual needs; coherent interdisciplinary programs are encouraged. The nonthesis option is available for the M.S. degree.

A basic minimum of 30 course credits is required for the Ph.D. degree, of which at least 12 must be in departmental courses. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Applications will be accepted from persons having backgrounds in chemistry or physics; chemical, mechanical, or aerospace engineering; material sciences; or earth sciences. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

FUEL SCIENCE (F SC)

400. Fuel Science Research and Design (1-10 per term)
410. Fuel Science Laboratory (1) *Mr. Polansky and Staff*
421. Flames (3) *Mr. Becker*
422. Combustion Engineering (3) *Mr. Essenhigh*
423. Combustion Laboratory (1) *Mr. Essenhigh*
424. Energy in Space Travel (3) *Mr. Vastola*
431. The Chemistry of Fuels (3) *Mr. Given*

504. (Gchem. 504) Organic Geochemistry of Coal (3) Interdisciplinary study of accumulation of organic sediments and their metamorphism into coal macerals; effects of environment; structure of coal macerals.

506. Carbon Reactions (3) Current approaches to heterogeneous reactions in combustion and gasification of carbons and graphite. Prerequisite: Chem. 452. *Mr. Walker*

512. High Temperature Kinetics and Flame Propagation (3) Laminar and turbulent premixed and diffusion flames; gaseous detonations; rate processes in high temperature gases. Prerequisite: F.Sc. 421. *Mr. Palmer*

514. Jet and Rocket Fuels (2) Propulsion systems; combustion chamber conditions; liquid and solid propellants, slurries, fuel sprays, and finely divided solids. Prerequisite: F.Sc. 421. *Mr. Palmer*

Note: *Courses in the use of X-ray diffraction, electron microscopy, spectroscopy, and electronic instrumentation in fuel science studies are listed under Materials Science.*

GENERAL ENGINEERING (GEN E)

Otis E. Lancaster
Chairman of the Committee on General Engineering
101 Hammond Building

Degrees Conferred: M.Ed., M.Eng.

This program is designed primarily to give academic preparation to those individuals who will teach engineering subjects in technical institutes and two-year colleges.

For either degree a minimum of 30 credits is required in addition to a scholarly written report. Twenty-four of these credits should be in engineering, physics, and mathematics. A candidate is expected to earn at least 3 credits each in mathematics, physics, and two fields of engineering, or demonstrate competence in them.

For the M.Ed. 6 credits must be in education, consisting of one 3-credit course in the theory of learning and teaching and one 3-credit course in internship in college teaching. Fifteen credits must be earned at the 500 level.

For the M.Eng. degree 6 credits may be taken in any field approved by the committee, but at least 12 credits in engineering subjects must be at the 500 level.

For admission an undergraduate degree in engineering, physical science, mathematics, or the equivalent is required. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

GENETICS (GENET)

Edward G. Buss, *Chairman of the Committee for Genetics*
203 Animal Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Buss, Cleveland, Creech, Dalton, Deering, Gerhold, Ginoza, Goodwin, Grun, R. R. Hill, Hunt, Marshall, R. Nelson, O'Mara, Person,

Rake, Rapp, Snipes, Starling, Therrien, Todd, Vesell, Walker, Wilson, Wright, and Zimmerman.

Graduate Faculty: Associate Members Ayers, Barnes, Costantino, Craig, Funk, Hargrove, Hepler, R. N. Hill, Johnson, Pfeifer, Risius, Shenk, and Thoele.

The program for genetics is an intercollege one, and faculty from the Colleges of Agriculture, Medicine, and Science serve as major advisers and on committees for the majors. The student is encouraged to select his major adviser.

Opportunities for graduate study and research are available in biochemical, developmental, molecular, population, cytogenetics, and pharmacogenetics. Organisms available for research include fungi; bacteria; viruses; fish; amphibia; rodents; birds; man; grain, forage, and horticultural plants; and forest trees. The graduate faculty committees for majors have the responsibility and jurisdiction for determining course work, specific requirements in communication skills exceeding the minimum, and research acceptable for satisfying degree requirements. The requirement in communication and foreign language skills for the Ph.D. degree may be satisfied by an ability to read and translate articles in at least one language in addition to English.

To be considered for admission to the genetics program a student should have 30 or more credits in biology and a combined total of 30 or more credits in chemistry, physics, and mathematics. Students with a grade-point average of 3.00 or better in biology, science, and communications courses and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Students with limited deficiencies may be admitted, but they must make up such deficiencies concurrently with their graduate studies.

The following genetics courses are available: Agro. 411, 509, 510; An.Sc. 422, 455; Biol. 405, 422, 425, 427, 428, 528; B.Chem. 503; Bphys. 430; C.Med. 503; For. 512; Hort. 407, 444, 507; Micrb. 516, 553, 556; Pharm. 515, 540; P.Path. 543. Twelve credits in these courses and 1 credit in genetics seminar are required for the M.S. degree in genetics or a minor in genetics for a Ph.D.; 15 credits in these courses and 3 credits in genetics seminar are required for a Ph.D. major in genetics. Transfer credits for courses in genetics may be accepted as substitutes for the above listed courses.

GEOCHEMISTRY (GCHEM)

Arthur L. Boettcher
In Charge of Graduate Programs in Geochemistry
211 Deike Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Barnes, Bates, Boettcher, Brindley, Burnham, Dachille, Greig, Griffiths, Keith, Langmuir, Muan, Newnham, Rose, Roy, Smith, Thornton, Wickman, and White.

Graduate Faculty: Associate Members Deines, Kerrick, Ohmoto, and Suhr.

Areas of specialization include crystal chemistry, phase equilibria, element distribution and affiliations, isotope geochemistry, geochemical prospecting, cosmochemistry, high-temperature and high-pressure geochemistry, and solid state technology.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages or by comprehensive knowledge of one. The nonthesis option is available for the M.S. degree.

GEOCHEMISTRY

Before starting graduate study, an applicant is generally expected to have had a standard introductory course in each of the following four subjects—chemistry, physics, geology, and mineralogy; 12 credits of intermediate-level work in any one or a combination of chemistry, physics, and geological science; and mathematics through integral calculus. Students who have taken somewhat less than the indicated minimum of subjects may be admitted but must make up their deficiencies concurrently with their graduate studies.

Students who present a 2.70 grade-point average in their basic science and geoscience subjects and other appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the 2.70 grade-point average may be made for students with special backgrounds, abilities, and interests.

GEOCHEMISTRY (GCHEM)

402. Introduction to Organic Geochemistry (3) *Mr. Given*

457. Geochemical Exploration (3) *Mr. Rose*

471. (Geol. 471) Field Studies in North America (3) *Mr. Smith*

502. (Geol. 502) Carbonates in the Marine Environment (3) Ancient carbonate rocks and recent carbonate sediments, with emphasis on modern field and laboratory methods and a multidisciplinary approach. *Mr. Weber*

504. (F.Sc. 504) Organic Geochemistry of Coal (3) Interdisciplinary study of accumulation of organic sediments and their metamorphism into coal macerals; effects of environment; structure of coal macerals. *Mr. Given*

512. (Mat.Sc. 512) Principles of Crystal Chemistry (2-4) Relation of structure to ionic size and nature; influence of pressure and temperature on structure; chemical-structural defects, crystalline solutions, phase-transitions. *Mr. Roy*

513. Phase Equilibria in Mineral Systems at High Temperatures (2-4) Interpretation of phase diagrams with emphasis on high-temperature oxide systems at atmospheric pressure; measurement of p-t-x, determination of equilibrium diagrams. *Mr. Muan*

514. Element Distribution in the Earth (3) Principles and data from studies of phase equilibria, petrology, and crystal structure as related to distribution of elements in minerals, rocks, and the earth. *Mr. Wickman*

517. Age Determinations (1-2) Geochemistry of radioactive elements and their daughters; age determination techniques and observations. *Mr. Deines*

518. Stable Isotope Geochemistry (3) Theory of isotope fractionation mechanisms; its application to a wide range of problems in the earth and planetary sciences. *Mr. Deines*

520. P-T-X Phase Equilibria (3) Phase equilibrium in mineral systems with pressure as a variable. *Mr. Boettcher*

522. Geochemistry of Aqueous Systems (2-3) Ionic and molecular equilibria related to stabilities and solubilities of minerals: Eh-pH, Po_2-pH relations applied to ground water, sea water, hydrothermal fluids. *Messrs. Barnes and Schmalz*

523. Water-Resource Geochemistry (2-4) Topics and problems concerning the chemical quality of surface waters and ground waters related to hydrogeologic and cultural controls. *Mr. Langmuir*

524. (Mat.Sc. 524) Vibrational Spectra of Materials and Minerals (2) Infrared and Raman spectroscopy of solid materials with applications to crystal chemistry, materials characterization and glass research. Prerequisites: Phys. 412, 471.

525. Electronic Properties of Minerals (2) Application of spectroscopy to mineralogy. Crystal field, EPR, NMR, Mossbauer spectra. Application to order-disorder, element distribution, mineral stability. Prerequisites: Phys. 412, 471.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in geochemical studies are listed under Materials Science.*

GEOGRAPHY (GEOG)

Wilbur Zelinsky, *Head of the Department*
442 Deike Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Deasy, Gould, Lewis, Miller, Rodgers, Simkins, Wernstedt, and Zelinsky.

Graduate Faculty: Associate Members Abler, Downs, and Williams.

The student may concentrate in subjects that call upon the special skills and interests of the staff. At the present time these include: geographic theory; methods of geographic analysis; the cultural geography of Anglo-America; population problems and the human use of the environment; microspatial behavior of individual actors in space; macrospatial analysis in regional and urban development; and regional development problems in Africa, Latin America, Southeast Asia, and Southern Europe. All students receive training in cartographic, statistical, and bibliographic techniques.

Students wishing to specialize in the field of population may also qualify for admission to a population issues program. This program is a course of study focusing on the social, economic, and geographical policy-related issues resulting from the dynamics of population trends, especially in developed nations. In addition to departmental admission requirements, the population issues committee evaluates the student's interest and aptitude for the training program, which consists of a minimum of 21 credits of interdisciplinary course work in population.

The student has the option for the M.S. degree to complete a thesis or a paper. The master's program is broadly based, designed to provide a beginning graduate student with basic training in systematic fields as well as in geographic theory and research techniques. This basic training underlies more specialized study at the doctoral level where a candidate selects two fields of concentration. A student may elect to specialize in the geography of a region only if faculty members have research experience in that region. The communication and foreign language requirement for the Ph.D. degree may be satisfied by either a reading competence in a modern foreign language with faculty approval or comparable facility in mathematics, statistics, or computer science.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

GEOGRAPHY (GEOG)

401. Historical Geography of North America (3) *Mr. Lewis or Mr. Zelinsky*
402. Cultural and Anthro-Geography (3) *Mr. Zelinsky*

405.	Geography of Population (3)	*Mr. Zelinsky or Mr. Simkins*
406.	Human Use of Environment (3)	*Mr. Knight*
407.	Geography of Settlement (3)	*Mr. Williams*
410.	Cartography—Map Design and Construction (3)	*Mr. Deasy*
412.	The Geography of the Future (3)	*Mr. Abler*
413.	Behavioral Approaches to Geography (3)	
420.	Urban Geography (3)	
427.	Geography of the Soviet Union (3)	*Mr. Rodgers*
428.	Geography of Eastern Europe (3)	
430.	Agricultural Geography (3)	*Mr. Knight*
433.	Regional Climatology (3)	*Mr. Wernstedt*
434.	Regional Physiography (3)	*Mr. Lewis*
440.	Geography of Middle America (3)	*Mr. Simkins*
441.	Geography of South America (3)	*Mr. Simkins*
442.	Regional Systems in Europe (3)	*Mr. Miller*
443.	Geography of the Orient (3)	*Mr. Wernstedt*
444.	Geography of Africa (3)	*Mr. Knight*
445.	Geography of Southern Asia (3)	*Mr. Wernstedt*
450.	Development of Geographic Thought (3)	*Mr. Abler*
451.	Map Interpretation (3)	*Mr. Lewis*
452.	Interpretation of Aerial Photographs (3)	*Mr. Deasy*
454.	Spatial Analysis I (3)	*Mr. Gould, Mr. Williams, or Mr. Strack*
455.	Spatial Analysis II (3)	
457.	Geographic Data Systems (4)	*Mr. Williams*
460.	Political Geography (3)	*Mr. Lewis*
470.	Industrial Location and Development (3)	*Mr. Rodgers*
475.	Geography of Communications Systems (3)	*Mr. Abler*
480.	Manufactural Systems Analysis (3)	*Mr. Miller*
489.	Problems in Geography (3)	*Staff*
497.	Directed Readings (1-9)	*Staff*

500. Introduction to Geographic Research (3)

501. Geographic Bibliography (1) An introduction to the techniques of bibliographic search and the writing of research papers in geography. Prerequisite: Geog. 500.

502. Regional Theory (3) Taxonomic methods of uniform—functional regionalization; canonical linkages; intraregional relationships; Wilson models of macro-canonical ensembles.

503. Advanced Regional Geography (3-12) Intensive study at an advanced level of selected regions or sections of the continents. Prerequisite: 12 credits in geography.

504. Physical Geography Seminar (3-12) The examination of current problems and theories in physical geography through critical discussion of the literature and student research.

505. Economic Geography Seminar (3-12) The examination of current problems and theories in economic geography through critical discussion of the literature and original student research.

506. Political Geography Seminar (3-6) The exploration of current problems and theory in political geography through critical discussion of the literature and original student research. Prerequisite: Geog. 460.

508. Cultural Geography Seminar (3-6) The exploration of current problems and theory in cultural geography through critical discussion of the literature and original student research.

509. Population Geography Seminar (3) Selected problems in population geography with emphasis on analysis and presentation of data. Prerequisite: Geog. 405.

517. Geographic Modeling (1) Spatial modeling, mapping and transformations of elementary geographic problems.

520. Metropolitan Analysis (3) Land use models, urban factorial ecology; intraurban movements; urban renewal, ghetto structure, residential change; commercial structure, blight. Prerequisite: Geog. 420 or 456.

567. Applied Quantitative Methods (3) Simulation, topological, queuing, programming, factor analytic, discriminant, and game theoretic models applied to geographic problems of spatial diffusion and interaction. Prerequisite: Geog. 456.

GEOLOGY (GEOL)

Robert F. Schmalz
In Charge of Graduate Programs in Geology
303 Deike Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Cuffey, Gold, Guber, Parizek, Ridge, Schmalz, Scholten, Spackman, Traverse, Voight, Weber, Williams, and Wright.

Programs are offered in stratigraphy, paleontology, sedimentation, paleobotany, palynology, regional and structural geology, geomorphology, ground water geology, engineering geology, marine geology and chemical oceanography, coal geology, coal petrology, and geology of metallic and nonmetallic deposits.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages or by comprehensive knowledge of one. The student has the option of a thesis or a paper for the M.S. degree.

For admission 25 credits in chemistry, physics, mathematics, and biological sciences, and at least 18 in geology and mineralogy are required. Students who have taken somewhat less than the indicated minimum in these subjects may be admitted but must make up their deficiencies concurrently with their graduate studies.

Students may be accepted with a previous degree in geophysics, physics, mathematics, engineering, earth sciences, or a closely allied field. Students whose grade-point average in courses pertinent to geology is below 3.00 will be considered for admission when there are strong indications that this average can be maintained at the graduate level. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

GEOLOGY (GEOL)

400.	Surface Geological Processes for Teachers (3)	*Mr. Weber*
401.	Earth History for Teachers (3)	*Mr. Cuffey*
402.	Field Methods for Teachers (3)	*Mr. Guber*
410.	Structural Geology (3)	*Mr. Gold*
420.	(Biol. 420) Paleobotany (3)	*Mr. Spackman*
421.	Introduction to Coal Petrology (3)	*Mr. Spackman*
423.	(Biol. 423) Introductory Palynology (3)	*Mr. Traverse*
430.	Paleontology (3)	*Mr. Guber*

435. Paleoecology (3)
440. Marine Geology (3) *Mr. Schmalz*
451. Economic Geology (3) *Mr. Ridge*
452. Introduction to Hydrogeology (3) *Messrs. Langmuir and Parizek*
453. Mechanics of Geological Materials (3) *Mr. Voight*
461. Geology of North America (3) *Mr. Wright*
462. Principles of Geomorphology (3-6)
470. Introduction to Field Geology (3) *Mr. Wright*
471. (Gchem. 471) Field Studies in North America (3) *Mr. Cuffey*
472. Field Geology (5) *Mr. Gold*
481. Geology of Oil and Gas (3) *Mr. Scholten*
490. Stratigraphy (3) *Mr. Williams*

502. (Gchem. 502) Carbonates in the Marine Environment (3) Ancient carbonate rocks and recent carbonate sediments, with emphasis on modern field and laboratory methods and a multidisciplinary approach. *Mr. Weber*

†503. Paleontology (3-9) Morphology of animal groups significant for their fossils; nature of species and faunal zones. Seminars may be arranged for studies of special fossil groups, microfossils, paleoecology. *Mr. Cuffey*

504. History and Foundations of Geology (2-4) Theoretical aspects of geology; spatio-temporal organization of matter, dynamic processes, sequential development; basic patterns and history of scientific thought. *Mr. Williams*

‡506. Sediments of the World (2-6) Evolution of sediments from Archean to Recent; relationship of sedimentation to geotectonism; kratonic and geosynclinal sediments; cyclicity. Prerequisites: Min. 512, 514. *Messrs. Scholten and Williams*

507. Seminar in Geomorphology (3-6) Classic and current literature in geomorphology.

511. Ore Deposits: Principles (3-6) Geological and geochemical processes controlling ore deposition; genetic classification of ore deposits. Prerequisite: Geol. 451. *Mr. Ridge*

512. Ore Deposits: Types (1-6) Geologic history and field examination of selected ore bodies; forming media; causes, sequences, and loci of emplacement; wall rock alteration; secondary enrichment. Prerequisite: Geol. 511. *Mr. Ridge*

524. Coal Petrology (1-6) Microscopy, source materials, coalification, constitution, classification of peats, lignites, bituminous coal, anthracite. *Mr. Spackman*

526. (Biol. 526) Problems in Palynology (1-6) Systematics; paleoecological palynology; Paleozoic palynology; Mesozoic and Cenozoic palynology; Pleistocene vegetational history. *Mr. Traverse*

540. Chemical Oceanography (3) Chemical reactions in sea water and at the sea floor related to sedimentation and diagenesis. *Mr. Schmalz*

545. Glacial Geology (3) Glaciers: their characteristics, causes, deposits, landforms, effects in periglacial regions. *Mr. Parizek*

546. Principles of Photogeology (3) Use of aerial photographs and mosaics in structural, geomorphic, and rock distribution studies and in compilation of maps. Prerequisites: Geol. 410, 462.

† Credits to be arranged, 3 to 6 per term.
‡ Credits to be arranged, 2-3 per term.

551. Dynamic Structural Geology and Geotectonics (3-6) Phenomena of fracturing, faulting, folding; stress and (finite) strain analysis, physical and analytical models; deformational environments; tectogenesis and orogenesis.
Messrs. Scholten and Voight

555. Advanced Structure and Petrofabrics (1-3) Macroscopic and mesoscopic recognition, measurement, and interpretation of small-scale rock structures and mineral orientation patterns in deformed rocks. *Mr. Gold*

571. Geology Field Trip (1 per year) Field study of regional geologic features with trips in successive years to differing geologic provinces.

581. Habitat of Oil (3) Geologic setting of petroleum as determined by basin tectonism, sedimentation, hydraulic and capillary forces, and reservoir textures.
Mr. Scholten

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in geological studies are listed under Mineralogy.*

GEOPHYSICS (GPHYS)

Shelton S. Alexander
In Charge of Graduate Programs in Geophysics
204 Mineral Sciences Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Alexander, Bell, and Howell.
Graduate Faculty: Associate Members Graham, Greenfield, and Lavin.

Students may specialize in seismology, physical properties of rocks, geophysical surveying, geomagnetism, paleomagnetism, geoelectricity, gravity, wave propagation, time-series analysis, space applications of geophysics, tectonics, earth physics, and planetary sciences.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages or by comprehensive knowledge of one. The nonthesis option is available for the M.S. degree.

For admission an applicant is generally expected to have had mathematics through differential equations; a standard introductory course each in physics, chemistry, and earth sciences; and at least 16 credits of intermediate-level work in any one or a combination of these subjects. Applicants who have taken somewhat less than the indicated minimum in these subjects may be admitted but must make up their deficiencies concurrently with their graduate studies.

Students may be accepted with a previous degree in geophysics, physics, mathematics, engineering, earth sciences, or a closely allied field. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Students with special backgrounds, abilities, and interests whose grade-point average in courses pertinent to geophysics is below 3.00 will be considered for admission when there are strong indications that a 3.00 average can be maintained at the graduate level.

GEOPHYSICS (GPHYS)

400. Physics of the Earth for Teachers (3) *Mr. Lavin*
406. Physics of the Earth (3) *Mr. Graham*
407. Well Logging (3)

408.	Geophysical Surveying (3)	*Mr. Lavin*
415.	Gravity and Magnetic Surveying (3)	*Mr. Lavin*
416.	Electrical Surveying (3)	*Mr. Greenfield*
417.	Seismic Methods (3)	*Mr. Lavin*
418.	Potential Theory Applied to Earth Problems (3)	*Mr. Alexander*

502. Seismic Instruments (3) Characteristics and design of seismometers and seismic recorders.

504. Communication Theory for Geophysicists (3) Basic theory of random processes leading to and including optimum filters; geophysical applications to gravity and seismic data analysis.

507. Seismology (3) Nature and transmission of seismic waves; cause and occurrence of earthquakes; applications in seismic prospecting.

508. Tectonics (3) Seminar in the cause and nature of the principal deformations of the earth.

516. Introduction to Nuclear Processes in Geologic Settings (2) Natural radioactivity and its measurement, interpretation, and use in research and exploration.

521. Thermal State of the Earth (2) Methods and instrumentation of geothermal measurements; geothermal observations; development of the theory of the thermal state of the earth.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in geophysical studies are listed under Mineralogy.*

GERMAN (GER)

Stanley R. Townsend, *Head of the Department*
S-323 Burrowes Building

Degrees Conferred: Ph.D., M.A., M.Ed.

Graduate Faculty: Senior Members Ebbinghaus, Preisner, Shelley, and Townsend.
Graduate Faculty: Associate Members de Levie and Kopp.

There is opportunity for major emphasis upon either literature or philology. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages.

Minimum qualifications for admission include 27 undergraduate credits in German beyond the intermediate level; provision is made, however, for admission with limited deficiencies. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Students may qualify for the M.A. and M.Ed. degrees either by writing a thesis—which is recommended if a student wishes to be considered for Ph.D. candidacy—or by submitting an essay to the department and taking additional 500-level German courses in lieu of 6 credits of thesis research.

GERMAN (GER)

401. Advanced Stylistics (3)
411. The Teaching of German (3)
430. History of the German Language (3)
443. (C.Lit. 443) Literary Relations of Germany with England and America (3-9)
454. Literature from the Age of Chivalry to the Thirty Years' War (3)
464. Literature from the Beginning of the Enlightenment Through Storm and Stress (3)
469. Goethe's Life and Works (3)
474. Classicism and Romanticism (3)
484. Literature from Realism to Expressionism (3)
495. Independent Study (1-9)

*1G. Elementary German for Graduate Students (3) Designed for students preparing to satisfy language requirements for advanced degrees.

*2G. Elementary German for Graduate Students (3) Continuation of Ger. 1G with opportunity for reading in special fields.

500. Bibliography and Research Techniques (3) Introduction to tools and methods of research, designed for students preparing for independent investigation of problems in German literature and language.

520. Introduction to Middle High German (3) Descriptive and historical grammar; readings in simple Middle High German texts.

521. Readings in Middle High German (3) Intensive reading in Middle High German literature, especially of the *Blütezeit*. Prerequisite: Ger. 520.

522. Old High German (3) Essentials of the grammar with special treatment of the High German sound shift and of ablaut and umlaut; reading of works written before 1100 A.D.

523. Gothic (3) Introduction to the historical and comparative Germanic grammar; emphasis on the Gothic language and texts. Suitable for advanced students in English.

525. Old Icelandic (3) Introduction to Old Icelandic grammar; readings in Old Icelandic prose. Suitable for advanced students in English.

531. Seminar in Medieval German Languages and Literatures (3-6)

541. Seminar in the Literature of the Reformation and Baroque (3-6)

551. Seminar in the Literature of the Enlightenment and the Age of Goethe and Schiller (3-6)

561. Seminar in Post-Idealistic Literature (3-6)

571. Seminar in Modern German Literature (3-6)

581. Seminar in Literary Genres (3-12) Special studies in the German lyric, drama, short story, and novel.

591. Seminar in German Literary Criticism (3)

595. Independent Study (1-9) Selected projects in the study of German literature and philology. Prerequisite: Ger. 500.

* No graduate credit is given for this course.

HIGHER EDUCATION (HI ED)

Larry L. Leslie
In Charge of Graduate Programs in Higher Education
319 Rackley Building

Degrees Conferred: D.Ed., M.Ed.

Graduate Faculty: Senior Members Anderson, Gillie, Ikenberry, Lutz, Sweitzer, Willower, and Yamamoto.

Graduate Faculty: Associate Members Flexner, Godbey, Leslie, Lindsay, and Mortimer.

The graduate program in the higher education major has as its goal the preparation of individuals who will pursue careers as administrators, faculty, or researchers in the nation's colleges and universities and in a variety of public and private agencies and associations. With emphasis on the systematic study of higher education, the program builds on the scholarly and scientific disciplines offered throughout the University and applies these studies to the professional functions and responsibilities which its graduates will assume.

With mounting awareness of the need for educational reforms and for improved teaching, other departments throughout the University encourage their graduate students to pursue a minor in higher education. The higher education faculty cooperates in this program—which is administered through the students' major departments—by offering a number of courses and seminars designed to promote understanding of post-secondary-school teaching.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be given priority for admission to the master's program; a grade-point average of 3.50 for master's work completed is preferred for admission to the doctoral program. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Some outstanding students may be admitted to the doctoral program with only the baccalaureate degree, but will earn the master's degree *en route*. For special requirements in the higher education major, write: Higher Education, The Pennsylvania State University, 319 Rackley Building, University Park, Pa. 16802.

HIGHER EDUCATION (HI ED)

545. Higher Education in the United States (2-3) A basis for all courses in higher education. Current issues are analyzed and trends of the future anticipated.

546. College Teaching (2-3) Principles involved in teaching at the college level; effective use of teaching aids; criteria used in evaluation.

547. Internship in Higher Education (1-9) Supervised experience in administrative offices, in research, on instructional teams, and in college teaching.

548. Curriculums in Higher Education (2-3) Various types of curriculums and philosophies underlying them; ways in which curriculums are developed; elective versus required courses; evaluation of achievement.

549. Community Junior College and the Technical Institute (2-3) Distinctive contributions to meeting the need for post-secondary education; development, functions, curriculum and instruction, government, administration and finance.

550. The Professions and the Education of Teachers (3) The nature of a profession and dimensions of professional education in the United States are explored. Trends and issues examined.

552. Administration in Higher Education (2-3) Philosophy of administration; principles of scientific management and their application in colleges and universities; case studies of administrative problems. Prerequisite: courses or experience in higher education.

554. The History of American Higher Education (3) An examination of the development of American higher education against the background of influential social, political, economic, and intellectual issues.

555. Seminar in Higher Education (1-6) Special topics in higher education.

556. College Students (3) Characteristics of college students; changes during college years; educational challenges and responses. Prerequisites: Hi.Ed. 545, Psy. 426, I.F.S. 435 or permission of instructor.

589. Problems, Projects, and Area Studies in Higher Education (1-6) Independent work in the study of topics in higher education, or development of new curriculums, materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of the department head.

HISTORY (HIST)

Kent Forster, *Head of the Department*
210 Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty: Senior Members Brown, Dahmus, Eggert, Forster, Frantz, Hassler, Maddox, McNall, Murray, Sun, and Utechin.

Graduate Faculty: Associate Members Ameringer, Borza, Duiker, Enteen, Goldschmidt, Green, Linker, Meier, Silverman, Spielvogel, and Stebbins.

Graduate work is offered in the following areas of history: ancient, medieval, Europe since 1500, Great Britain and the British Empire, Russia and Eastern Europe, the Middle East, the Far East, the United States, and Latin America. These areas are subdivided into chronological, national, and topical fields.

The candidate for the M.A. or M.Ed. degree selects one of the above areas for his master's examination. He must take some courses in an area in history other than his examination area and in a cognate field. (The cognate field for an M.Ed. candidate must be in education.) With the consent of his adviser, a master's candidate may substitute additional course work and a paper for a thesis.

The candidate for the doctor's degree must pass examinations in one of the above areas, in a thesis field within that same area, and in one field from a second area. He must also pass an examination in a single cognate field, or in a study area made up of a number of academic disciplines related to the subject of his thesis. The communication and foreign language requirement for the Ph.D. may be satisfied by a reading knowledge of two foreign languages or one language and work in quantitative techniques. The D.Ed. candidate has no foreign language requirement; however, he must minor in education.

The entering student should present evidence of undergraduate course work covering the history of Europe from ancient times to the present and the history of America from its discovery to the present. Students with a 3.00 junior-senior average and better than a 3.00 average in all undergraduate history courses and appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students.

Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Each applicant must provide Graduate Record Examination scores and at least three letters of recommendation.

HISTORY (HIST)

400. Selected Topics in History (3-6)
401. Classical Civilization (3) *Mr. Borza*
403. The Middle Ages from Constantine to the Crusades (3) *Mr. Dahmus*
404. The Middle Ages from the Crusades to the Renaissance (3) *Mr. Dahmus*
405. Byzantine Civilization (3)
408. Intellectual History of the Middle Ages (3) *Mr. Dahmus*
410. The Renaissance (3) *Mr. Spielvogel*
411. The Reformation (3) *Mr. Spielvogel*
413. The Age of Absolutism (3) *Mr. Green*
414. The French Revolution and the Napoleonic Era (3) *Mr. Green*
417. Nineteenth Century Europe (3) *Mrs. Rosenblatt*
419. Recent European History (3) *Mr. Forster*
422. History of the American Frontier (3) *Mr. McNall*
425. History of American Political Parties (3)
426. The Diplomatic History of the United States to 1900 (3) *Mr. Maddox*
427. The Diplomatic History of the United States Since 1900 (3) *Mr. Maddox*
428. American Military History (3) *Mr. Hassler*
430. Colonial America to 1753 (3) *Mr. Frantz*
431. Revolutionary America, 1753-1783 (3) *Mr. Frantz*
432. The Formative Period of American History (3) *Mr. Brown*
433. The Middle Period of American History (3) *Mr. McNall*
434. The United States in Civil War and Reconstruction (3) *Mr. Hassler*
435. The Emergence of Modern America (3) *Mr. Eggert*
436. America Between the Wars (3) *Mr. Murray*
437. Recent American History (3) *Mr. Murray*
439. History of England in the Middle Ages (3) *Mr. Dahmus*
440. Britain Under the Tudors and Stuarts, 1485-1688 (3) *Mr. Linker*
441. Great Britain, 1688-1832 (3) *Mr. Linker*
442. History of Russia to 1700 (3) *Mr. Utechin*
443. Imperial Russia, 1700-1917 (3) *Mr. Utechin*
444. Eastern Europe in Modern Times (3) *Mr. Enteen*
447. Social and Economic History of Europe Since 1750 (3) *Mr. Silverman*
448. Intellectual and Cultural History of Modern Europe (3) *Mrs. Knight and Mr. Silverman*
449. Diplomatic History of Europe Since 1870 (3) *Mr. Forster*
452. Social and Cultural History of the United States Since 1783 (3) *Mr. Brown*
453. American Economic History in the Agricultural Era (3) *Mr. McNall*
454. American Economic History in the Industrial Era (3) *Mr. Eggert*
456. (L.M.R. 456) History of American Labor (3) *Mr. Eggert*
458. Constitutional History of the United States to 1877 (3) *Mr. Stebbins*
459. Constitutional History of the United States Since 1877 (3) *Mr. Stebbins*
460. Latin America and the United States (3) *Mr. Ameringer*
462. Mexico and the Caribbean Nations in the Twentieth Century (3) *Mr. Ameringer*
463. Spanish Conquest of the New World (3)
464. Latin American Independence Movements (3)
467. Alexander the Great and the Hellenistic World (3) *Mr. Borza*

468. The Roman Republic (3) *Mr. Borza*
469. The Pax Romana (3)
470. The Later Roman Empire (3)
471. Nineteenth Century China (3) *Mrs. Sun*
472. Twentieth Century China (3) *Mr. Duiker*
479. Modern Vietnam, Laos, and Cambodia (3) *Mr. Duiker*
480. History of Arabic Civilization, 600-1258 (3) *Mr. Goldschmidt*
481. The Ottoman Empire and Other Muslim States (3) *Mr. Goldschmidt*
482. The Contemporary Middle East (3) *Mr. Goldschmidt*
485. History of Central and East Africa (3) *Mr. Griffith*
486. History of West Africa (3) *Mr. Griffith*
491. History of the Soviet Union (3) *Mr. Enteen*
492. Great Britain Since 1832 (3) *Mr. Linker*
497. Germany Since 1640 (3) *Mr. Silverman*

501. Historical Method (3) *Mr. Meier*

502. Historiography (3) *Mr. Meier*

503. Studies in Medieval English History (3-6) A seminar in the political, economic, and cultural history of England in the Middle Ages. *Mr. Dahmus*

504. Medieval Civilization (3-9) *Mr. Dahmus*

505. The Age of the Reformation (3-6) *Mr. Spielvogel*

507. Studies in European History, 1600-1750 (3-6) *Mr. Green*

508. Studies in European History, 1750-1900 (3-6) *Mr. Silverman*

509. Studies in Twentieth Century Europe (3-6) *Mr. Forster*

512. Studies in Pennsylvania History (3-6) *Mr. Frantz*

520. Colonial and Revolutionary America (3-6) *Mr. Frantz*

533. The United States, 1783-1860 (3-6)

534. The United States, 1860-1877 (3-6) *Mr. Hassler*

535. The United States, 1877-1919 (3-6) *Mr. Murray*

536. The United States Since 1919 (3-6) *Mr. Murray*

538. Diplomatic History of the United States (3-6) *Mr. Maddox*

539. Economic History of the United States (3-6) *Messrs. McNall and Eggert*

540. Studies in British History (3-6) *Mr. Linker*

544. Seminar in Eastern European History (3-6) *Messrs. Utechin and Enteen*

545. Studies in Russian and Soviet History (3-6) *Messrs. Utechin and Enteen*

552. Cultural History of the United States (3-6) *Mr. Brown*

559. Studies in Constitutional History (3-9) A graduate seminar examining constitutional developments in their historical context through readings, class discussions and research papers. *Mr. Stebbins*

562. Seminar in Latin-American History (3-6) *Mr. Ameringer*

563. Studies in the History of the Caribbean Area (3) Prerequisites: Hist. 22, 23. *Mr. Ameringer*

568. Studies in Greek History (3-6) *Mr. Borza*

569. Studies in Roman History (3-6) *Mr. Borza*

571. Studies in Asian History (3-9) *Mrs. Sun*

581. Studies in Middle Eastern History (3-6) *Mr. Goldschmidt*

HOME ECONOMICS EDUCATION (HE ED)

Marjorie East, *Head of the Department*
212 Rackley Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Member East.
Graduate Faculty: Associate Members Ray and Shear.

Research and graduate courses may be chosen to give emphasis to special areas of interest in home economics education, such as curriculum development; evaluation; teaching at the elementary, secondary, adult, or higher education levels; supervision; administration in colleges; or research.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign languages.

Students who have majored as undergraduates in some aspect of home economics and who have achieved a grade-point average of at least 2.50 in their junior and senior years will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. Students wishing to be admitted to the doctoral programs must have completed a master's degree and will be admitted subject to limitations of departmental facilities. Exceptions will be made for students with special backgrounds, abilities, and interests.

HOME ECONOMICS EDUCATION (HE ED)

400v. Special Problems in Home Economics Education (1-3)
406v. Audio-Visual Methods for Home Economics (1-4)
410v. Supervision of Student Teachers (1-3)
427v. Teaching Home Economics (3)
443v. Adult Education in Home Economics (3)
463v. Senior Seminar (2)
466v. Student Teaching (9)
477v. Curriculum Development for Home Economics in Secondary Schools (3)
478v. Appraising Student Progress in Home Economics (3)
479v. Readings in Home Economics Education (1-4)
480v. Problems in Teaching Home Economics (3-6)
481v. Employment Preparation Programs in Vocational Home Economics (3)

502, 502v. Home Economics Instruction at the College Level (3) Teaching techniques suitable for college instruction in home economics; for prospective home economics college teachers.

503, 503v. Home Economics Teacher Education (3) Organization of college programs of teacher education; use of resources; records; field services; recruitment and selection of personnel. Prerequisite: two years' experience in teaching home economics.

504, 504v. Educational Issues and Home Economics (3) Contemporary issues in education and their relationship to the teaching of home economics. Prerequisite: teaching experience.

510, 510v. Educational Leadership in Home Economics (2-6) Principles of educational leadership for home economics preparing for administration; supervision of city and state programs; supervision of student teachers. Prerequisites: graduation from a four-year teacher education major and two years' teaching experience in home economics.

511, 511v. Internship in Home Economics Supervision and Administration (2-8) Opportunity to understudy an educational leader in student teacher supervision, state supervision, department or college administration, or regional consultation. Prerequisite: H.E.Ed. 510.

518, 518v. Evaluation of Home Economics Programs (3) Methods of evaluating progress toward goals in home economics education and use of findings in program planning and revision.

521, 521v. Home Economics Education Seminar (2-3) Selected topics and recent developments in home economics education. Conferences and guidance relative to individual research problems.

530, 530v. Problems in Home Economics Education (1-6 per term) Individual investigation of problems related to the teaching, supervision, or administration of home economics education.

HORTICULTURE (HORT)

Darrell E. Walker, *Head of the Department*
103 Tyson Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members Bergman, Grun, Hitz, Larson, McArdle, Ritter, Shannon, Smith, Stinson, Tukey, and Walker.

Graduate Faculty: Associate Members Beelman, Craig, Haramaki, Hatch, Hepler, Kuhn, Martsolf, Mastalerz, Pfahl, and White.

Students may specialize in climatology, propagation, several phases of production, fruit and vegetable processing, plant genetics and breeding, plant nutrition, and various environmental and post-harvest physiological studies of horticultural crop species.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by one of three options: (1) comprehensive competence in one language, (2) reading examination or two-course sequence in two languages, or (3) reading examination or two-course sequence in one language plus 6 credits in other communications skills.

Students wishing additional credits in floriculture, olericulture, ornamental horticulture, plant breeding and genetics, plant nutrition, climatology, or pomology should register for Hort. 501.

HORTICULTURE

Prerequisites for admission vary according to the area of specialization; but basic courses in physical sciences, mathematics, and biological sciences are required. Students who lack prerequisite courses may be admitted but are required to fulfill deficiencies without degree credit.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

HORTICULTURE (HORT)

401. Plant Propagation (3) *Mr. Haramaki*
402. Plant Nutrition (3) *Mr. Bergman*
403. Horticultural Plants and Their Environment (3) *Mr. Mastalerz*
404. Advanced Horticultural Crop Science (3-12) *Mr. Walker*
405. Senior Seminar in Horticulture (1-2)
407. Plant Breeding (3) *Mr. Hepler*
412. Post-Harvest Physiology (3) *Mr. Ritter*
444. Advanced Plant Breeding (3-6) *Mr. Craig*
447. Problems in Horticulture (1-9)
451. Flower Store Management (4) *Mr. Pfahl*

501. Experimental Problems in Horticultural Science (1-12) Investigation of problems in floriculture, olericulture, ornamental horticulture, plant breeding, nutrition, or pomology. *Mr. Walker*

506. Nutrition of Horticultural Crops (2-4) Principles, applications, and interpretations of diagnostic methods for determining fertilizer requirements of horticultural crops. *Mr. Smith*

507. Physiological Genetics and Plant Breeding (3) Physiological genetics in improving the biological efficiency and utilization of plants. Prerequisites: Bioch. 42 or Biol. 442, 6 credits in genetics and/or plant breeding. *Mr. Creech*

512. Principles of Fruit and Vegetable Storage (2-4) Principles involved in the maturation, storage, and senescence of fruits and vegetables, and their application. *Mr. Ritter*

514. Propagation and Improvement of Horticulture Plants (1-6) Biological factors affecting sexual and asexual propagation of plants; techniques in plant improvement; maintenance of propagation material.

517. Horticultural Seminar (1 per term) Review of current research publications in horticulture. Each student presents one or more reviews of assigned topics.

520. Genetics and Breeding Seminar (1 per term) Review of research and literature in genetics and breeding of horticultural crops.

524. Experimental Procedures in Horticultural Research (3) *Mr. Craig*

525. Horticultural Research Techniques (3) Practice in and comparison of methods and apparatus used in horticultural research. Winter term, even years. *Mr. Tukey*

528. Problems in Fruit and Vegetable Processing (2-12) *Mr. McArdle*

HUMAN DEVELOPMENT AND FAMILY STUDIES (HD FS)

JOSEPH H. BRITTON
In Charge of Graduate Program in Human Development and Family Studies
S-105E Human Development Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Bortner, Britton, de Lissovoy, Ford, Gottlieb, B. Guerney, Gunter, Harms, Harris, Knoll, Peters, Stein, W. Smith, Taylor, Urban, and Walcher.

Graduate Faculty: Associate Members Gage, L. Guerney, Hickey, Hultsch, Neisworth, Seward, R. Smith, and Vondracek.

This interdisciplinary program is concerned with the study of individuals and families and with ways in which their development and welfare can be promoted. The perspective encompasses the individual life-span and the full life cycle of the family. It includes variations in patterns of functioning and the use of resources; the impact of diverse social, economic, and cultural contexts upon behavior; and conditions as well as professional procedures which bring about positive and constructive development. Emphasis is upon the integration of knowledge from various fields for the purpose of understanding and developing professional skills for careers in research and scholarship, in teaching, in program planning and evaluation, or in other professional services. The faculty includes persons in the behavioral and social sciences.

The student is expected to include courses in both individual development and family studies and to emphasize one area of study or professional orientation. He may specialize in research and teaching in the area of the family—family relationships or family economics and management; or in infant, child, or adolescent development; or in adult development and aging. He may be preparing for professional work as a consultant on individual, family, or community problems; for a leadership role in developmental and educational programs for children, adolescents, or adults.

Infant and preschool laboratories are operated as part of the teaching and research program. Each unit has observational facilities and rooms for study of individual and group behavior of children and adults. Home management houses provide opportunities for research and for guiding undergraduate students in an experience in group living and in managing household resources. The Individual and Family Consultation Center provides facilities for the development and evaluation of educational programs for remediation of individual and family problems by professional and paraprofessional persons. The Institute for the Study of Human Development, the Center for Human Services Development, and the Pennsylvania Field Research Laboratory provide opportunities for participation in research and evaluation projects. Additional resources, such as the Psychology Clinic, the Special Education Center for Children, the Speech and Hearing Clinic, the Division of Counseling, and the Computation Center, are available in other parts of the University.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign languages.

Entering students should have at least 6 credits in the biological and physical sciences, 12 in the social sciences (and, depending upon proposed area of emphasis, basic courses in sociology, psychology, and economics), and 6 in developmental and family studies. Students not meeting these requirements may be admitted with limited deficiencies to be made up concurrently with their graduate work.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be

accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

INDIVIDUAL AND FAMILY STUDIES (I F S)

410. Communities and Families (3)
411. The Helping Relationship (3)
413. Dysfunctions in the Developmental Process (3)
414. Resolving Individual and Family Problems (3)
415. Child Development and Family Relationships for Secondary Schools (3)
416. (C.S. 416) Consumer Role of Family (3)
418. Family Relationships (3)
419. Problems of Family Financial Management (3)
420. Problems in the Analysis of Individual Development (3-9)
424. Economic Conditions in Relation to the Family (3)
427. Conceptions in Development (3)
428. Infant Development (3)
429. Advanced Child Development (3)
430. Practicum in Preschool Groups (1-6)
432. Developmental Problems of Normal Children (3)
435. Developmental Transition to Adulthood (3)
439. Family Resource Management (2)
441. Organization Planning for Preschool Programs (3)
442. Home Management Experience (3)
445. (Psy. 445) Development Throughout Adulthood (3)
477. Analysis of Family Problems (2-9)
481. Developmental Programming for Preschool Children (3)

500. Nonthesis Research (1-9)

501. Seminar: Issues in the Study of Individual and Family Development (1-3) Reading, reports, and discussion of conceptual frameworks for multidisciplinary and developmental study of individuals and families.

504. Practicum in Program Development for Preschool Children (2-6) Investigation, analysis, and report on the design, development, and evaluation of a selected program for preschool children. Prerequisites: 6 credits of individual development and I.F.S. 430, 441.

506. Projects in Design and Evaluation of Programs for Preschool Children (2-4) Individual projects in the design, implementation, and evaluation of different teaching approaches with varying groups of children. Prerequisites: I.F.S. 504 and 3 credits in research methods.

508. Parental Education (1-6) Implementing educational and preventive programs for parents; discussion and evaluation of theory and techniques.

511. Modifying Conjugal Life (1-9) Conceptual foundations, research procedures, and practicum experience in teaching effective communication and problem-solving skills in the marriage relationship. Prerequisites: 6 credits in individual development or psychology and 3 credits in statistics.

512. Filial Relationship Modification (1-9) Theory, research, and practicum in teaching parents to resolve developmental problems in their own children. Prerequisites: 6 credits in individual development or psychology and 3 credits in statistics.

513. Group Procedures in Individual Development (1-6) Theory, research, and practicum experience in the use of group methods for promoting individual development in different age groups. Prerequisites: I.F.S. 411 and research methods or statistics.

515. Teaching Individual Development and Family Studies (1-6) Objectives, techniques, materials, and evaluation in teaching at the secondary and college level, and in adult and public education programs.

520. Seminar in Prenatal and Infant Development (1-6) Prenatal and infant development, with emphasis on multiple determinants of early development and their relationship to later behavior. Prerequisites: 6 graduate credits in individual development, psychology, or biological science and 3 credits in statistics.

522. Seminar in Dysfunctional Processes in Individual Development (1-6) Multiple processes involved in dysfunctional development in the individual across the life-span. Prerequisite: I.F.S. 413.

524. Theoretic Analysis of Family Economic and Managerial Behavior (3) Conceptual approaches and major contributions to the study of the organizational, managerial, and economic functions of the family. Prerequisite: I.F.S. 418 or 424 or 477.

525. Theories of Family Relationships (3) Assessment of the utility of major theories for empirical analysis of interpersonal interactions among family members. Prerequisite: I.F.S. 418.

528. Teaching Home Management (2-3) Development and evaluation of teaching objectives and methods in college and adult-level home management courses.

529. (Psy. 529) Seminar in Child Development (1-6) Readings and reports on recent findings in child development. Prerequisites: 6 graduate credits in child development, child psychology, or educational psychology, plus 3 in statistics.

530. Independent Study in Individual and Family Studies (1-9) Problems involving individual study. Prerequisite: instructor's approval of proposed study.

532. Field Projects in Individual and Family Studies (1-9) Supervised research or internship in human services program. Prerequisite: instructor's approval of proposed project.

536. (Psy. 536) Research Methods in Developmental Processes (3) Methodological issues in research on varying stages of development across the individual life-span. Prerequisites: 6 credits in individual development or psychology and a course in statistics.

539. Seminar in Adolescent Development (1-6) Cultural, psychological, and biological aspects of the developmental transition to adulthood. Prerequisites: 6 credits in individual development or psychology and 3 credits in sociology and statistics.

543. Modification of Family Managerial Practices (1-3) Conceptual issues, research, and practicum experience in assisting families in the solution of financial and managerial problems.

544. Seminar in Dysfunctional Patterns in Family Organization (1-6) Processes of familial dysfunction and disorganization and their explanation in economic, social-psychological, and managerial terms. Prerequisite: I.F.S. 418 or 424 or Soc. 430.

545. Families and Socioeconomic Systems (1-6) Functional interrelationships between families and social and economic systems. Prerequisites: I.F.S. 418, 424.

546. Seminar in Family Relationships (1-9) Interpersonal interaction within family systems throughout the life cycle. Prerequisite: I.F.S. 418.

549. (Psy. 549) Developmental Theory (3) Conceptual frameworks and major contributions to the study of individual development across the life-span. Prerequisite: 6 credits at the 400 level in individual development or psychology.

550. Seminar in Family Economics and Management (1-6) Recent developments in the study of family economic and managerial practices.

579. Seminar in Adult Development and Aging (1-9) A seminar dealing with specific topics concerning adult development and aging. Prerequisites: I.F.S. 445 and statistics.

HUMANITIES (HUMAN)

Nancy M. Tischler
In Charge of Graduate Programs in Humanities
Capitol Campus, Middletown, Pa. 17057

Degree Conferred: M.A.

Graduate Faculty: Senior Members Chen, Dordevic, Lear, Richman, Tischler, and G. Wolf.

Graduate Faculty: Associate Members Anderson, Eisenstein, Knight, McAree, and M. Wolf.

This program aims at developing skills in the interdisciplinary study of art, music, literature, and philosophy. Entering students are expected to have considerable background in at least two of these areas. A committee will meet with each student to determine his individual needs and arrange a program designed to help him develop essential skills, such as analysis and criticism of music, art, literature, and philosophy; classification of works into genres, periods, and schools; evaluation of works by applications of appropriate criteria; and synthesis and generalization. For students who plan to teach in a junior college, there is also provision for an internship program.

A series of seven 500-level courses are designed to help a student develop a number of these skills. In addition, his adviser may suggest he enroll in certain 400-level courses or in independent studies with qualified faculty.

Each student is required to submit a master's production (a critical paper or a creative work accompanied by a paper) which will demonstrate his competence in humanistic study. A committee will judge this production.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

This program is available only at the Capitol Campus.

HUMANITIES (HUMAN)

500. Research Methods (3) Study of the methods and materials of scholarship, compilation of bibliographies, writing of scholarly papers, and proper documentation.

501. Presuppositions in the Humanities (3) Assumptions about knowledge, reality, and value which influence the humanist in his choice of ideas, methods, and modes.

502. Perennial Issues in the Humanities (3) Recurrent issues viewed in terms of their significance to the artist, historian, and the philosopher.

503. Interrelations in the Humanities (3) An interdisciplinary study of the interdependence of aesthetic values in various art forms as they exist in cultural settings.

520. Studies in Style (3) Study of prominent stylistic patterns, evaluating the essence of a style, and the varied responses of the artist and philosopher within a pattern.

525. Studies in Aesthetics (3) Study of certain techniques in the arts that presuppose certain aesthetic concepts and certain ideas that demand parallel form.

580. Master's Production (1-6) An original scholarly master's paper or creative production initiated by the student, supervised by an appropriate professor, and judged by a committee.

EDUCATION (ED)

520. Seminar in Junior College Teaching (3) The history of the two-year college, responsibilities of the teacher in the college organization, and methods of teaching.

550. Internship in Junior College (3) Teaching humanities courses in a two-year college under a master teacher, who will direct, criticize, and evaluate the intern.

INDUSTRIAL ARTS EDUCATION (IA ED)

Robert L. Lathrop
In Charge of Graduate Programs in Industrial Arts Education
240 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Associate Members Koble and Shemick.

Emphasis may be placed on research, curriculum development, or teacher education. The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign languages.

Graduation from an approved major in industrial arts and at least 18 credits in education and related psychology are required for admission. Students with a 2.75 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.75 grade-point average may be made for students with special backgrounds, abilities, and interests.

Graduate Record Examination scores on both aptitude and education sections are required of D.Ed. and Ph.D. candidates.

INDUSTRIAL STUDIES (I S)

400. Planning and Management of Instructional Resources (3)
410. Technology in the Elementary School (3)

440. Independent Study in Industrial Studies (2)
450. Selected Topics in Industrial Studies (1-6)

INDUSTRIAL ARTS (I ART)

574. History and Philosophy of Industrial Arts (2-3) Historical developments and concurrent educational philosophies of industrial arts in American education. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

575. Problems in Industrial Arts Education (2-3) Subject matter, projects, methods of manual and informational teaching, aids and devices, selection of text and reference materials, personnel organization, shop management, problem pupils. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

576. Supervision and Administration of Industrial Arts Education (2-3) How to organize, supervise, and administer functioning programs of industrial arts; duties of a supervisor and director of industrial arts. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

577. Testing in Industrial Arts (2-3) Construction of informal manipulative and written tests; use of standardized mechanical aptitude and achievement tests; construction and use of rating scales; scoring and gradings; interpretation of test results. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

578. Research in Industrial Arts (2-3) Research techniques in industrial arts education. Prerequisite: 6 credits in professional courses in industrial arts.

580. Seminar in Industrial Arts (1-9) Directed intensive study, investigation or research in selected phases of the program; reports and constructive criticism. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

INDUSTRIAL ENGINEERING (I E)

Benjamin W. Niebel, *Head of the Department*
207 Hammond Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Draper, Ham, Lancaster, Niebel, and Rosenshine.
Graduate Faculty: Associate Members Addison, Freark, Guild, Raphael, Thuering, and Zindler.

Graduate study and research are conducted in operations research-management science, production engineering, process design, systems engineering, and human engineering.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by an intermediate knowledge of one foreign language.

Graduates in industrial engineering, other engineering curriculums and mathematics who present a 2.50 junior-senior average will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

INDUSTRIAL ENGINEERING (I E)

400. Engineering for Production (3)
402. Engineering Economy (3)
403. Engineering Economy and Statistics (3)
404. Management Science (3)
405. Linear Programming (3)
406. Design of Production and Distribution Systems (3)
407. Quantitative Methods for Operations Research (3)
422a,b,c,d,e,f. Industrial Engineering Problems (2-12)
423. Quality Control (3)
424. Job Evaluation (3)
425. Introduction to Operations Research (3)
426. Industrial Automation (3)
427. Solidification of Castings (3)
428. Foundry Engineering (3)
432. Introduction to Reliability Engineering (1-3)
438. Metal Cutting Principles and Practice (3)

501. Manufacturing Methods (2-8) Special projects including investigation; experimentation, design, and research of one or more special types of manufacture.

502. Management Methods (3-6) Scientific management, including management controls and mathematical programming; research on special problems.

503. Industrial Relations (1-6) Study of human problems related to labor unions, hierarchy, specialization; analysis of organizational structure, policies, decision criteria, and communication systems.

504. Advanced Quantitative Methods in Industrial Engineering (3) Study of statistical and analytical decision models important in industrial engineering with emphasis on inference and testing of hypotheses. Prerequisites: Math. 62 and 3 credits in statistics.

506. Advanced Work Design and Measurement (3-9) Methods of research in motion and time study; critical analysis of current literature.

507. Analysis of Decision Processes (3-6) An introductory study of decision theory and its applications. Models and analyses of decisions under assumed certainty, risk, and uncertainty. Prerequisites: I.E. 323, 402.

508. Operations Research I (3) The study of deterministic optimization models in operations research including allocation, inventory, sequencing and replacement models. Prerequisite: I.E. 425.

509. Operations Research II (3) The study of probabilistic optimization models in operations research including network, inventory, waiting lines, forecasting and game theory models. Prerequisite: I.E. 425.

510. Mathematical Programming (3) Study of advanced topics in linear programming including duality, decomposition, sensitivity analysis, parametric programming, and selected topics in mathematical programming. Prerequisite: I.E. 405.

511. Experimental Design in Engineering (3) Statistical design and analysis of experiments in engineering; experimental models and experimental designs using the analysis of variance. Prerequisites: Math. 63 and 3 credits in statistics.

512. Graph Theory and Networks in Management Science (3) Prerequisite: I.E. 405.

513. Real Time Data Processing for Engineering Systems (3) Random access computers and communication components for real time systems; engineering systems simulation on digital computers. Prerequisite: Cmp.Sc. 102 or 410.

515. Complex Linear Flow Models (3) Application of complex linear flow models in engineering and management science, including static and dynamic system simulations. Prerequisite: I.E. 512.

516. Applied Stochastic Processes I (3) Prerequisites: I.E. 323, Stat. 418.

517. Applied Stochastic Processes II (3) Prerequisite: I.E. 516.

518. Plastic Deformation Processes (3) Study of the principles, theories, technology, design, and application of plastic deformation processes to shape metals. Prerequisite: undergraduate engineering degree.

528. Metal Cutting Theory (3) Study of the theory of metal cutting, contemporary and future problems of metal removal processes; critical analysis of current literature. Prerequisite: I.E. 438.

538. Experimental Investigations in Materials Processing (3) Experimental investigation on selected subjects in processing involving instrumentation, methods, and analysis. Prerequisite: I.E. 528.

JOURNALISM (JOURN)

Robert M. Pockrass
In Charge of Graduate Programs in Journalism
220 Carnegie Building

Degree Conferred: M.A.

Graduate Faculty: Senior Members Barnes and Harrison.
Graduate Faculty: Associate Members Dulaney, Froke, Goodwin, Norris, Pockrass, and Smith.

The program is flexible so as to meet the needs of students with various undergraduate or professional backgrounds. Candidates may select a 30-credit thesis program or a 36-credit nonthesis program. Generally, the thesis program is for those with an undergraduate major or professional experience in journalism or communications, or for those who plan to pursue a doctorate. Its purpose is to provide an understanding of the structure and functions of communications in modern societies, and a strong minor in an appropriate field is normally required. The nonthesis program is usually selected by candidates with undergraduate majors in the humanities or social sciences and who now wish intensive professional training for a journalistic career. All candidates must take at least one course dealing with research into communications problems. Other requirements are tailored to the individual's background, interests, and goals.

Students who achieved at least a 2.50 junior-senior average in an appropriate undergraduate field of study will be considered for admission. Those with lower averages will be considered if their achievements since graduation recommend them. Applicants must submit an autobiographical statement of about 1,000 words indicating career objectives and type of program preferred.

JOURNALISM (JOURN)

401. Critics and Ethics of the Mass Media (3) *Mr. Harrison*

405. International Mass Communications (3)
406. Evaluation and Uses of Mass Communications Research (3) *Mr. Colldeweih*
419. (Spch. 419) Comparative Broadcasting Systems (3)
421. Editorial Interpretation (3) *Mr. Harrison*
422. Cultural Aspects of the Mass Media (3) *Mr. Pockrass*
424. Public Affairs Reporting (3)
430. Journalism in the Schools (3-6)
436. (Soc. 436) Sociology of Opinion Formation (3)
442. Special Topics in Advertising (3)
443. Advertising Campaigns (3)
444. Advertising in Contemporary Society (3) *Mr. Norris*
460. Photography for the Mass Media (3)
466. Public Relations Problems (3) *Mr. Gibbs*
468. Law of Mass Communications (3) *Mr. Smith*
470. Reporting of Contemporary Issues (3)
481. News Editing and Evaluation (3)
492. Public Affairs Broadcasting (3) *Mr. Farson*
499. Independent Study in Mass Communication (2-6) *Mr. Goodwin*

504. Seminar in the History of Mass Communication (3) *Mr. Harrison*

505. International Communication Problems (3) Legal and communications problems of the international flow of news and opinion; international press codes.

506. Introduction to Mass Communications Research (3) The scientific method; survey of basic concepts of theoretical and empirical research; variety of methodology; criteria for adequate research. *Mr. Barnes*

508. The Literature of Journalism (3)

510. Mass Communications Research Methods I (3) Design of research on processes and effects of mass communications; data analysis and hypothesis testing. Prerequisite: Journ. 506 or Stat. 400. *Mr. Barnes*

511. Mass Communications Research Methods II (3) Problems of bibliographical research; evaluation of sources and materials in mass communications history, biography, structure, ethics, and other areas. Prerequisite: Journ. 506.

513. Constitutional Problems of the News Media (3) Problems involving conflict between guarantees of press freedom in the First and Fourteenth Amendments and rights and privileges of others. *Mr. Harrison*

521. News Media and Public Opinion (3) Problems in the function, techniques, and responsibilities of press, radio, and television in forming and interpreting opinion. Prerequisite: Pl.Sc. 427. *Mr. Pockrass*

524. Government and Mass Communications (3) Problems of freedom of information; governmental efforts to control mass communication agencies; government news coverage; public information agencies. *Mr. Smith*

540. Seminar in Advertising Problems (3) *Mr. Norris*

545. Advertising and Consumer Behavior (3) Examination of theories of human behavior as they apply to the study of advertising's effects on consumer behavior.

585. Comparative Theories of Press Systems (3) Institutional structure and normative functions of press systems in modern societies, as shaped by prevailing world view and social organization. *Mr. Norris*

LABORATORY ANIMAL MEDICINE (L A M)

C. Max Lang, *Chairman, Department of Comparative Medicine*
The Milton S. Hershey Medical Center

Degree Conferred: M.S.

Graduate Faculty: Senior Member Lang.
Graduate Faculty: Associate Members Andrews and Bullock.

The department offers a postdoctoral program for veterinarians leading to the Master of Science degree with a major in laboratory animal medicine. Laboratory animal medicine is a specialty of veterinary medicine that is concerned with the biology of laboratory animals and their comparative relationships to man. Postdoctoral training in this discipline provides a broad, basic foundation upon which the individual can build a career in teaching and research in laboratory animal medicine and/or in the professional direction of research animal facilities. The program has a strong research-oriented base with emphasis on comparative medicine and pathology.

The program requires two years for completion. Basically, the first year consists of formal course work, while the second year is devoted mainly to research and the development of clinical skills and techniques. A student must have earned a minimum of 12 credits in a major subject, 6 credits in a minor subject, and 6 credits of thesis research in order to receive the graduate degree. Approved minors have been established in anatomy, behavioral science, biological chemistry, microbiology, pathology, pharmacology, and physiology.

Students with a 2.75 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.75 grade-point average may be made for students with special backgrounds, abilities, and interests.

This program is offered only at The Milton S. Hershey Medical Center.

COMPARATIVE MEDICINE (C MED)

501. Biology and Care of Laboratory Animals (2) Presentation of the anatomic and physiologic characteristics of the commonly used laboratory animal species and their relation to biomedical research.

503. Laboratory Animal Genetics (2) Genetic principles applied to laboratory animals used for investigations of diseases that may be controlled or influenced by genetic factors.

505. Laboratory Animal Zoonoses (2) Experimentally induced, spontaneous, and infectious diseases transmissible between man and animals with special emphasis on etiology, differential diagnosis, and control.

507. Techniques of Laboratory Animal Experimentation (2) Techniques of drug administration, infusion, and collection of body fluids and materials; gnotobiology; use of radioisotopes and bioinstrumentation.

510. Animal Physiological Surgery (3) Selected operative procedures, demonstrating principles of physiology with modern biomedical instrumentation, will be followed through the postoperative period.

515. Experimental Surgery of Laboratory Animals (3) Surgical techniques, including nephrectomy and Goldblatt clamp, bladder and gastric pouches, bile duct cannulation, intraventricular operation, cardiac and cerebrovascular catheterization.

530. Diseases of Laboratory Animals, I (3) Physiological and pathological expressions of both infectious and metabolic-degenerative disease of rodents, with emphasis on diagnostic and control methods.

531. Diseases of Laboratory Animals, II (3) Physiological and pathological expressions of both infectious and metabolic-degenerative disease of nonhuman primates and other species of animals.

535. Comparative Pathology (3) Comparative pathologic characteristics of infectious and metabolic disease of animals and man.

540. Seminar (1 per term) Student and faculty discussions of organization and presentation of data on recent advances in selected topics of laboratory animal medicine.

570. Special Topics (1-6) Specialized training in advanced research techniques and current status of research in the various areas of laboratory animal medicine.

590. Research Problems (1-12) Research training will be given to enable the student to advance his knowledge about some aspect of laboratory animal medicine.

LINGUISTICS (LING)

Simon Belasco
In Charge of Graduate Programs in Linguistics
309 Burrowes Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Belasco, Borden, Brault, Brubaker, Cofer, Dalbor, Ebbinghaus, Hammer, Holtzman, Magner, Morrill, Palermo, Schmalstieg, and Sturcken.
Graduate Faculty: Associate Members Martin and Schnitzer.

A student majoring in linguistics may specialize in one of several flexible interdisciplinary graduate programs. The M.A. degree program includes general courses in historical linguistics, generative phonology and syntax, psycholinguistics, and acoustic phonetics. A candidate will also select, with the help of his graduate adviser, a coherent set of electives in a specialized area which may be a language or a related field. He will submit an acceptable thesis or paper and pass a written comprehensive examination.

In addition to the courses required for the M.A. degree in linguistics (or the equivalent), each candidate for the Ph.D. degree must take the following courses: Ling. 503 if he has selected Ling. 504 or vice-versa, Ling. 505 (Seminar in Historical Linguistics), Spch. 520 (Seminar in Speech Science), and at least two 500-level courses in the structure, phonology, and history of a language or language family other than his native language if he specializes in a related area, and at least five 500-level courses in the related area. If he specializes in a language area, he must take at least two 500-level courses in the structure, phonology, and history of a language or language family other than his native language or language area and at least five 500-level courses in his language area. The specialized area will be selected by the candidate with the approval of his doctoral committee. The doctoral comprehensive examinations will be both written and oral and will cover the synchronic and diachronic aspects of general linguistics as well as the candidate's specialized area. The thesis must represent a significant contribution to linguistic knowledge. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of either French, German, Spanish, or Russian and another major language related to the candidate's professional interests.

LINGUISTICS

The minimum requirement for admission to an advanced degree program will normally be a B.A. degree in linguistics or an equivalent in any of the interdisciplinary subjects recognized as a specialized area.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

LINGUISTICS (LING)

400. Introduction to Transformation Grammar (3)
402. Historical Linguistics (3)
420. (Psy. 420) Advanced Psycholinguistics (3)

500. Generative Linguistics (3) Types of grammatical rules and their interrelations; algorithm for assigning structural descriptions; evaluation procedure for selecting best compatible grammar.

503. Generative Syntax (3) Grammatical rules specifying well-formed strings; conditions on analyzability and assigning of structural descriptions; deviation from well-formedness. Prerequisite: Ling. 400.

504. Generative Phonology (3) Distinctive feature theory in the generative framework; articulatory and acoustic correlates; nonphonemic features. Prerequisite: Ling. 400.

505. Seminar in Historical Linguistics (3) Detailed study of some problem of historical linguistics, e.g., the laryngeal theory, Indo-European ablaut, etc. Prerequisite: one course in historical linguistics.

520. (Psy. 520) Seminar in Psycholinguistics (3) The relationship between the behavioral, probabilistic view and the structuralist, deterministic view of language as a system of habits.

595. Seminar in Interdisciplinary Linguistics (3-12) Methods of research. Common and individual investigations in interdisciplinary fields of linguistics in consultation with one or more interdisciplinary instructors. Prerequisite: Ling. 400.

MAN-ENVIRONMENT RELATIONS (M E R)

Raymond G. Studer, *Director of the Division*
S-126 Human Development Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Arnold, Densmore, Esser, McBride, Studer, Vallance, and Wohlwill.

Graduate Faculty: Associate Members Coblentz, Funkhouser, Mann, Powers, Smith, and Van Dommelen.

Graduate instruction and research opportunities are available in the application of tools and knowledge in the basic sciences to the understanding and organization of various man-environment systems. This broad, interdisciplinary program deals with the effects of man-made environments upon human biological, behavioral, and social outcomes. Included is the development of methodological and empirical resources

required to realize and maintain environmental support systems for various human goals and settings. Students in this program may develop general competences in man-environment relations (environmental analysis and management), or specialize in clothing studies or food service management. These areas of specialization have been organized under a unifying structure to provide an interdisciplinary, integrative base (see courses 500-516). Specialization in clothing provides an approach to understanding the role and technical requirements of clothing for individuals, families, industries, and nations. Specialization in food service provides professional training for management positions in hospitals, educational systems, and other public and private settings. Specialization in housing provides training for professionals involved in programming, planning, and managing the micro and macro aspects of large-scale housing systems in both the public and private sectors. The communication and foreign language requirement for the Ph.D. may be satisfied by options selected from designated areas including but not restricted to foreign languages. The thesis or paper option is available for the M.S. degree.

Undergraduate preparation may be in one of the above or related areas, in the physical, behavioral or social sciences, or in environmental and urban studies. Deficiencies, assigned on an individual basis, may be removed concurrent with graduate studies. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

CLOTHING AND TEXTILES (CL TX)

400. Special Problems in Clothing and Textiles (1-6)
408. Intermediate Textiles: 408L (2), 408P, (1-3)
410. Clothing for the Family (3)
415. Functional Clothing Design (3-12)
416. Western Costume Development from the Renaissance to the Present (3)

HOUSING AND INTERIORS (H I)

401. Advanced Interiors I (3)
402. Advanced Interiors II (3-9)
470. Housing Problems and Policies (3)

FOOD SERVICE AND HOUSING ADMINISTRATION (FS HA)

402. Food Service and Housing Layout and Design (3)
410. Advanced Quantity Food Production (3)
412. Food and Beverage Operations (3)
435. Financial Management in Hospitality Industries (3)
442. Hospitality Merchandising (3)
461. Personnel Functions in Food Service and Housing Administration (3)
470. Problems in Food Service and Housing Administration (3)

MAN-ENVIRONMENT RELATIONS (M E R)

500. Nonthesis Research (1-6)

501. Problems in Man-Environment Relations (1-9) Individual directed study, investigation and practice in selected aspects of man-environment relations.

502. Seminar in Man-Environment Relations (1-9)

503. Research Methods and Evaluation in Man-Environment Relations (1-9)

505. Environmental-Behavioral Programming, Design, and Management (3) Applications of findings in the behavioral sciences to environmental design and management strategies; empirical, theoretical, and methodological issues. Prerequisites: M.E.R. 510, 515.

510. Psychological Foundations of the Study of Environment-Behavior Relations (3) Seminar relating the psychology of perception, cognition, motivation, personality, attitude formation, and psychological stress to aspects of the physical environment.

515. Environmental Systems Theory (3) An in-depth review of those elements of general systems theory relevant to the analysis and organization of man-environment settings.

516. Quantitative Methods in Environmental Management (3) The use of operations research and systems analysis in the modeling of man-environment systems. Prerequisite: M.E.R. 515.

520. Recent Developments in Textiles (3) Developments in fibers, yarns, fabrics, finishes; effects on use and care; discussions and reports based on current literature.

521. Clothing Behavior (3) Analysis and interpretation of clothing behavior through application of theories selected from the behavioral sciences.

522. Clothing Production, Distribution and Consumption Systems (3) Problems connected with manufacture and consumption of clothing; interrelation of textile and clothing trades with other industries.

523. Societal Determinants in Clothing and Textile Development (1-6)

525. Textile Technology (6)

540. The Proximate Housing Environment (3) Evaluation of useful objects in respect to their form, function, and time; selection for exhibition.

541. Aesthetic Aspects of Housing (3) Approach based upon human needs with consideration of materials in the light of their use in home living.

MATHEMATICS (MATH)

Paul Axt, *Head of the Department*
227 McAllister Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty: Senior Members Anderson, Andrews, Armentrout, Axt, C. Ayoub, R. Ayoub, S. Chowla, Deutsch, Fine, Grilliot, Hahn, Hammer, Hunter, James, Kanwal, A. Krall, H. Krall, Lallement, Morris, Petrich, Ribeiro, and Rung.

Graduate Faculty: Associate Members Kalmbach, Mack, Maserick, McCammon, McLaughlin, Olson, and Stevens.

Graduate courses in all the principal branches of mathematics are offered regularly each year. The department is prepared to direct research in a variety of fields, including various branches of analysis, algebra, topology, number theory, numerical

analysis, applied analysis, algebraic geometry, and mathematical logic and foundations. A digital computer is available on the campus for students interested in numerical methods.

Entering graduate students in mathematics for whom English is not the first language are required to have a score of at least 550 on the TOEFL (Test of English as a Foreign Language) examination. Furthermore, the results of this examination must be received by the Department of Mathematics at least six months prior to the requested date of admission to the Graduate School. The paper or thesis option is available for the M.A. degree.

To be admitted to the Ph.D., D.Ed., or M.A. program without undergraduate deficiency, an applicant should have completed at least 18 credits in mathematics at the advanced undergraduate level (400 series) or their equivalents. The undergraduate student is urged to take at least 6 credits in foundations of analysis (Math. 420-421) and 6 in modern algebra (Math. 480-481) or their equivalents. These courses are essential to prepare for the graduate program and, if they are taken after admission, only 6 credits at most may be counted toward an advanced degree. All first year students working toward the Ph.D., D.Ed., or M.A. degree are required to enroll in Math. 489 for two successive terms.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

All Ph.D. students, before they have accumulated 48 graduate credits earned at the University or elsewhere, to satisfy the communication and foreign language requirement must take qualifying examinations in three fields of mathematics and demonstrate a reading knowledge of one foreign language (French, German, or Russian). Recommendations for advancement to Ph.D. candidacy are based on these examinations. The comprehensive examination is given after approximately 60 credits and only after the student has passed a reading examination in a second of the foregoing languages.

For the D.Ed. degree, a student must pass qualifying examinations in algebra and analysis and a reading examination in French, German, or Russian before he is allowed to take the comprehensive examination. In addition to the major thesis, the department requires participation in two terms of research seminar, but no minor thesis is required.

For the M.A. degree the department offers two options: (1) The thesis option requires 12 credits of approved 500-series courses in mathematics, 6-9 credits of thesis, sufficient credits in approved 400- or 500-series courses to make a total of 30 credits, and a final oral examination based on the thesis and general course material, and (2) The nonthesis option requires 18 credits of 500-series courses in mathematics with a grade of A or B, sufficient credits in approved 400- or 500-series courses to make a total of 30 credits, and a term paper of an approved topic in mathematics. No final examination is given in this option.

To be admitted to the M.Ed. program without undergraduate deficiency, an applicant should have completed at least 15 credits in mathematics at the intermediate level beyond calculus. The M.Ed. program does not require any 500-series courses, but the student is encouraged to select some at this level. Special courses have been instituted for the training of teachers. Among these are Math. 400, 401-402, 416, 425-426, and 470-471. These are acceptable for the satisfaction of credit requirements only for the M.Ed. degree.

MATHEMATICS (MATH)

400. Probability for Teachers (3)
401-402. Geometry for Teachers (3 each)
404. Theory of Numbers (3)

405. (A.M. 405) Fourier Series and Partial Differential Equations (3)
406. Topics in Theory of Numbers (3)
409-410. (Stat. 409-410) Introduction to Mathematical Statistics (3 each)
411. Finite Differences (3)
412. (Stat. 412) Introduction to Mathematical Statistics (3)
413-414. Mathematics of Science for Teachers (3 each)
416. Mathematical Logic for Teachers (3)
417. (A.M. 417) Tensor Analysis (3)
418. (A.M. 418, Stat. 418) Discrete Probability Theory (3)
420-421. Introduction to Analysis (3 each)
425-426. Analysis for Teachers (3 each)
427. (Stat. 427) Discrete Stochastic Models (3)
428. (Phil. 428) Logical Theory (3)
431. (A.M. 431) Ordinary Differential Equations (3)
435. Axiomatic Set Theory (3)
441. (A.M. 441) Matrix Algebra (3)
452. (A.M. 452) Functions of a Complex Variable (3)
453. (Cmp.Sc. 453) Numerical Computations (3)
454. (Cmp.Sc. 454) Matrix Computations (3)
470-471. Algebra for Teachers (3 each)
472. Foundations of Geometry (3)
473. Elementary Point-Set Topology (3)
480-481. Introduction to Modern Algebra (3 each)
489. Mathematics Seminar (1-6)
490. Topics in Mathematics (3-9)
491. Topics in Applied Mathematics (3-9)

501-502. Theory of Functions of a Real Variable (3 each) Sets, metric spaces, measure and integration, Lp spaces and other function spaces, differentiation. Prerequisite: Math. 421.

503. Fourier Analysis (3) Fourier series and integrals, convergence and summability, theorems on Fourier coefficients, uniqueness properties. Prerequisite or concurrent: Math. 502.

505. Integral Equations (3) Fredholm and Volterra equations, and applications. Prerequisite: Math. 421.

507. Calculus of Variations (3) Prerequisite: Math. 421.

508-509. Complex Analysis (3 each) Analytic and meromorphic functions; Riemann's mapping theorem. Prerequisite: Math. 421.

511. Linear Algebra (3) Vector spaces and linear transformations, canonical representations, elementary divisors and invariant factors. Prerequisite: Math. 481 or 537.

515. Partial Differential Equations of Mathematical Physics (3) Methods of solution of selected elliptic, parabolic, and hyperbolic partial differential equations, with reference to physical application. Prerequisite: Math. 421.

517-518. (Stat. 517-518) Probability Theory (3 each) Measure theoretic foundation of probability, distribution functions and laws, types of convergence, central limit problem, conditional probability, special topics. Prerequisites: Math. 452, 501.

520. Projective Geometry (3) General study of the subject from the synthetic and analytic standpoint. Prerequisites: Math. 472, 480.

523. Metric Differential Geometry (3) The usual classical treatment of the subject. Prerequisite: Math. 63.

524. Advanced Complex Analysis (3) Topics include boundary behavior of analytic functions, bounded analytic functions, conformal mapping, theory of Riemann surfaces. Prerequisite: Math. 509.

525. Theory of Functions of Several Complex Variables (3-6) Topics include fundamental properties of holomorphic functions, complex analytic manifolds, integral representations, Cousin problems. Prerequisite: Math. 509.

529-530-531. Topology (2 each) Topological, product, compact, metric, and connected spaces; continuous functions; separation axioms, countability conditions, combinatory topology.

532. Theory of Sets (3) Formal development of set theory on a logical basis and related methodological problems; applications to the foundations of mathematics. Prerequisite: Math. 428.

535-536-537. Algebra (2 each) Basic theory of semigroups and groups, rings and modules, fields, lattices. Prerequisites: Math. 480 (535) and 481 (536).

538. Commutative Algebra (3) Topics selected from noetherian rings and modules, primary decompositions, Dedekind domains and ideal theory, other special types of commutative rings or fields. Prerequisite: Math. 536.

539. Rings (3) Selected topics from the theory of rings. Prerequisite: Math. 536.

540. Valuation Theory (3) Selected topics from the theory of valuations on a field including completeness, extensions, ramification, local and global fields, adeles and ideles.

542-543. (Stat. 542-543) Statistical Distribution Theory (3 each) Random variables and expectations; discrete, continuous, univariate, multivariate, exact, and asymptotic distribution theory. Prerequisites: Math. 421 and 441 or 481.

544-545-546. General Topology (2 each) Topics selected including uniform spaces, function spaces, and proximity spaces. Prerequisite: Math. 531.

547-548-549. Lie Theory (2 each) Topics selected from theory of topological semigroups, topological groups, lie groups, transformation groups. Prerequisite: Math. 531.

550. (Phil. 550) Foundations of Mathematical Logic (3) The nature of logical basis of mathematics; critical examination and development of the basic parts of logical calculus. Prerequisite: Math. 480 or 428.

552. (Cmp.Sc. 552) Numerical Analysis I (3) Interpolation; remainder theory; approximation of functions; error analysis; orthogonal polynomials; approximation of linear functionals; functional analysis applied to numerical analysis. Prerequisites: Math. 420, 453.

553. (Cmp.Sc. 553) Numerical Analysis II (3) Eigenvalue and eigenvector determination; numerical solution of integral equations and ordinary differential equations with error and stability analysis. Prerequisites: Math. 420; Math. 454 or 481.

554. (Phil. 554) Logic and Metamathematics I (3) Completeness, Löwenheim-Skolem, Herbrand, and compactness theorems; first-order theories; categoricity, elimination of descriptions; decidability; algebraic and geometric applications. Prerequisite: Math. 428.

556. (Phil. 556) Recursion Theory (3) Recursive functions; normal form, enumeration and separation theorems; partial recursive functions; recursion theorems; special recursive functions; alternate formulations; related topics. Prerequisite: Math. 428.

557. (Phil. 557) Logic and Metamathematics II (3) Arithmetization; Gödel and Tarski incompleteness theorems; undecidability results; Gentzen-type systems and consistency results. Prerequisite: Math. 428.

558-559. (Stat. 558-559) Theory of Stochastic Processes (3 each) Stationary, independent, and orthogonal processes; discrete and continuous Markov processes; martingales and semi-martingales applications. Prerequisite: Math. 518.

560-561. Theory of Differential Equations (3 each) Topics selected from existence and uniqueness of solutions of differential systems, Sturm-Liouville systems, eigenvalue problems, integral operator solution. Prerequisites: Math. 72 or 83 or 100, and 508.

562. Theory of Special Functions (3) Topics include asymptotic expansions; Riemann-Papperitz and Trusdell's F equations; orthogonal polynomials; generating, beta, zeta, hypergeometric, Bessel, Legendre, elliptic functions. Prerequisites: Math. 72 or 83 or 100 and either Math. 420 and Math. 452 or Math. 508.

563. (Cmp.Sc. 563) Approximation Theory (3) Approximation in normed spaces; existence, uniqueness, characterization, computation of best approximations; error bounds; degree of approximation; approximation of linear functionals. Prerequisites: Math. 453, 501.

564. (Cmp.Sc. 564) Numerical Solution of Partial Differential Equations (3) Numerical solution of initial and boundary-value problems; eigenvalues and eigenfunctions; errors, stability, and convergence. Prerequisite: Math. 552.

565. Functional Analysis (3) Theory of Banach and Hilbert spaces, including functionals and operators, and related topics. Prerequisite: Math. 502.

570. Special Topics in Geometry (3-12)

571. Special Topics in Analysis (3-12)

572. Special Topics in Algebra (3-12)

573. Special Topics in Applied Mathematics (3-12)

574. Special Topics in Foundations of Mathematics (3-12)

575-576. Mathematics Seminar (1-6 each) Selected topics from recent mathematical developments.

577. (Stat. 577) Special Topics in Probability (3-12) Special topics in probability which are not offered regularly but which are of special interest to faculty and students.

578. Special Topics in Topology (3-12)

579. (Cmp.Sc. 579) Special Topics in Numerical Analysis (2-12)

580. Special Topics in Number Theory (2-12)

581-582. Group Theory I, II (3 each) Selected topics from group theory including Abelian, solvable, nilpotent, and free groups, Sylow theorems, and group extensions and representations. Prerequisite: Math. 535.

583. Homological Algebra (3) Modules, diagrams, functors, homology of complexes, resolutions, cohomology of groups, tensor and torsion products. Prerequisite: Math. 536.

584-585-586. Algebraic Topology (2 each) Development of singular and Cech homology and cohomology theories; homotopy and cohomotopy theories. Prerequisite: Math. 531.

587-588-589. Point Set Topology (2 each) Topics selected from point set topology including upper semicontinuous and continuous decompositions, theory of continua, dimension theory. Prerequisite: Math. 531.

591. (Stat. 591) Seminar in Probability Theory (1-6) Lectures on current and recent research in various special topics in probability theory.

592-593-594. Number Theory (3 each) Congruences, quadratic residues, arithmetical functions, Dirichlet's theorem, prime number theorem, classical multiplicative ideal theory, partitions, valuations and p-adic numbers, divisors. Prerequisite: Math. 480. Prerequisite or concurrent: Math. 508.

Note: *Courses in Applied Mathematics, Computer Science, and Statistics are listed separately.*

MATHEMATICS (MATH)

Helmut E. Weber
In Charge of Graduate Programs in Mathematics
King of Prussia Graduate Center
King of Prussia, Pa. 19406

Degree Conferred: M.Ed.

Graduate Faculty: Associate Members Callahan, Duncan, and Llorens.

The program is offered specifically to permit teachers in the area to pursue advanced studies through evening classes while employed in teaching. Courses offered for the program are established and controlled by the resident departments at the University Park Campus.

Credit requirements may be satisfied by completing a minimum of 18 credits in approved mathematics courses, a minimum of 6 credits in approved mathematics and science courses, and a minimum of 6 credits in approved education courses. In addition, a term paper is required. All requirements must be met within six years or seven consecutive summers.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. An applicant must have a bachelor's degree and have completed 27 credits in mathematics including at least 15 credits at the intermediate level beyond calculus. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Further details concerning this program may be obtained by writing directly to the Graduate Center.

MECHANICAL ENGINEERING (M E)

Donald R. Olson, *Head of the Department*
207 Mechanical Engineering Building

Degrees Conferred: Ph.D., M.S., M.Eng.

MECHANICAL ENGINEERING

Graduate Faculty: Senior Members Brickman, Brighton, Cunningham, DiIlio, Faeth, Heinsohn, Jonsson, Lestz, McLaughlin, Meyer, Moroz, Olson, Reethof, Schmidt, and Shearer.

Graduate Faculty: Associate Members Bowlus, DeCarolis, Park, Parke, Wambold, and Wolgemuth.

Graduate programs and research facilities are available in thermodynamics and combustion, heat transfer, fluid mechanics, dynamic system analysis, mechanical design, biomedical engineering, automatic controls, and fluid amplifiers. Air pollution control, automotive safety, designing for noise control and for reliability also provide many research and design opportunities.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by an in-depth study of one foreign language (9-12 credits) or by taking three or more courses (minimum of 9 credits) of a nontechnical nature in a single area of study appropriate and related to the student's career orientation.

A student working toward an M.S. degree may choose one of the following options: (1) a minimum of 24 course credits plus 6 thesis credits (M.E. 600) culminating in the submission of a thesis to the Graduate School or (2) a minimum of 30 course credits plus submission of a scholarly written report to the department. A Ph.D. thesis research proposal may serve as the written report provided the student has passed the candidacy examination.

The entering student must hold a bachelor's degree in engineering or physical science. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

MECHANICAL ENGINEERING (M E)

401. Mechanical Engineering (3-12)
402. Air Conditioning and Life Support Systems (3)
403. Rocket Propulsion (3)
405. Small Particle Technology (3)
409. Gas Turbines (3)
410. Power Plants (3)
411. Refrigeration (3)
412. Heat Transfer (3)
413. Internal Combustion Engines (3)
417. Theory of Engineering Instruments (3)
418. Principles of Turbomachinery (3)
421. (Aersp. 421) Intermediate Viscous Flow (3)
450. Design of Machine Tools (3)
451. Advanced Machine Design Problems (3)
452. Design Analysis (3)
455. Automatic Control Systems (3)
458. Noise Control in Machinery (3)
460. Reliability Concepts in Design (3)
470. Introduction to Air Pollution Control (3)
472. Engineering and Administration of Air Pollution Control (8)

503. Thermodynamic Process Analysis (3) Development of equations governing separate processes in complete machines to give basic system parameters and characteristics; transient processes; irreversible effects.

504. Advanced Engineering Thermodynamics (3-6) Pure and applied thermodynamics including its application to advanced engineering problems; collateral reading and discussion of the classical works on the subject. Prerequisite: M.E. 42.

506. Selected Topics in Mechanical Engineering (1-12) Advanced courses adapted to the individual requirements of graduates in mechanical engineering.

512. Heat Transfer—Conduction (3) One- and two-dimensional conduction heat transfer for steady state and transient systems with varying boundary conditions.

513. Heat Transfer—Convection (3) Laminar and turbulent flow heat transfer in natural and forced convection systems.

514. Heat Transfer—Radiation (3) Thermal radiation fundamentals; specular and diffuse systems; differential and integral methods; numerical techniques; industrial applications.

519. Compressible Fluid Flow (2-4) Two-dimensional subsonic flow; similarity rules; theory of characteristics; supersonic and hypersonic flows; nonsteady flow; oblique shock waves.

521. Electromagnetic and Thermodynamic Flow Systems (3) Thermodynamic equations for flow of reacting and nonreacting fluids in electromagnetic fields; applications to engineering problems.

522. Boundary Layer and Separated Flows (3) Behavior of viscous fluids, with emphasis on boundary layer and separation effects in internal flow.

540. Simulation of Mechanical Engineering Phenomena (3) Analog and numerical methods for simulation of problems in thermodynamics, heat transfer, fluid mechanics, diffusion, and machine dynamics.

550. Analysis of Design Problems (3) Case problems in machine design requiring integrated application of engineering knowledge.

552. Advanced Dynamics of Machines (3-6) Linear and torsional vibrations in and balancing of rotating and reciprocating machinery; exact analysis of stresses produced by these and other dynamic forces in machine parts. Prerequisites: E.Mch. 12, M.E. 54.

553. Friction and Lubrication (3) Sliding and rolling surface phenomena; hydrostatic, hydrodynamic, and magnetohydrodynamic lubrication theory; design and control of gas and fluid lubricated bearings.

555. Automatic Control Systems (3) Advanced problems and techniques in the design of automatic control systems with emphasis on stability, controller design, and optimum performance. Prerequisite: M.E. 455.

556. Advances in Control Systems Analyses (3) Control system theory and applications of newly developed theory to engineering systems; nonlinear systems, distributed systems, state-space methods. Prerequisite: M.E. 555.

557. Mechanism Synthesis (3) Geometrical and algebraic methods for synthesizing planar and spatial mechanisms, dynamics of spatial mechanism.

558. Fluid Control Systems (3) Systems elements, simplified models, analysis of interacting elements, instrumentation; computer-aided case study, and experimental investigations. Prerequisite: M.E. 455.

560. Probabilistic Methods in Machine Design (3) Reliability determination of machines for various types of interfering stress and strength probability func-

tions. Probabilistic life consumed modeling. Prerequisites: Math. 409 or M.E. 460 or I.E. 323, M.E. 42, 54.

571. Air Pollution Seminars (1-2) Weekly seminars featuring the contributions of many different disciplines to the solution of air pollution and other environmental problems.

580. Investigation Projects (2-6) Special experimental studies or investigations in mechanical engineering, adapted to individual requirements.

MEDICAL TECHNOLOGY (MED T)

Eugene H. Cota-Robles
In Charge of Graduate Programs in Medical Technology
S-101 Frear Building

Degree Conferred: M.S.

Graduate Faculty: Senior Members Anthony, Cota-Robles, Grun, Hayes, Ludwig, McCarl, O'Mara, Pazur, Stone, Wickersham, and Zimmerman.
Graduate Faculty: Associate Member Pootjes.

This is an interdisciplinary program designed for the registered medical technologist to obtain further academic training and some research experience. Students should expect to spend approximately one year (3 terms) at the University Park Campus taking course work and a second year at a cooperating hospital school doing a research problem for the master's thesis. Opportunities are available for course work and research in biology, biochemistry, clinical chemistry, immunology, microbiology, physiology, and virology. Research at the hospital school is under the joint supervision of a clinical scientist at the hospital and a University staff member.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. In addition to the bachelor's degree, candidates should be registered Medical Technologists (ASCP) and have had at least one year of laboratory experience following registration. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

For courses offered see majors in biochemistry, biology, biophysics, chemistry, and microbiology.

METALLURGY (METAL)

William R. Bitler
In Charge of Graduate Programs in Metallurgy
221 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Bitler, Healy, Hoke, Muan, Ryba, and Simkovich.

This program is one of the options in which a graduate student in the Department of Material Sciences can receive an advanced degree. A student may specialize, through both course work and research, in the science and engineering aspects of

chemical, physical, or mechanical metallurgy.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language together with courses from other designated areas.

Suitable preparation for graduate study in this program may be found in one of the material sciences such as ceramic science, fuel science, metallurgy, or solid state science; in engineering fields such as chemical or mechanical engineering; in basic physical sciences such as chemistry or physics; or in earth sciences such as geochemistry and mineralogy. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

METALLURGY (METAL)

401. Metallurgical Processes and Kinetics (3)
402. Electrometallurgy, Hydrometallurgy, and Corrosion (3)
404. Pyrometallurgy (3)
405-406. Metallography (3 each)
407. Metallurgical Engineering I (3)
408. Metallurgical Engineering II (3)
410. Metallurgical Investigations II (3)
412. Solid-State Metallurgy (3)
420. Particulate Systems in Mineral Processing (3)
421. Particle Technology Laboratory (1-3)
423. Recent Developments in Mineral Processing (3)
424. (Min.E. 424) Coal Preparation (3)
425. Interfacial Phenomena and Flotation (3)
459. Metallurgical Applications for Engineers (3)
460. Pollution Control in the Mineral Process Industries (3)

501. Metallurgical Problems (1-6 per term) Independent study of special problems in metallurgy.

502. Seminar in Metallurgy (1-6) Conferences, reading, reports, and special lectures.

508. Kinetics of Phase Transformations (3) Application of statistical mechanics and absolute rate theory to kinetics of phase transformations, including diffusion, nucleation, and growth rates. *Mr. Bitler*

509. Introductory Theoretical Physical Metallurgy (3) Quantum mechanics and its application to solid-state theory; introduction of Schroedinger's equation, its solutions, free-electron model, band model. *Mr. Bitler*

510. Magnetic and Transport Properties of Materials (3) Treatment of the magnetic and transport properties of solids by quantum mechanics with applications to practical alloy development. Prerequisite: Metal. 509. *Mr. Bitler*

511. Advanced Physical Metallurgy (3) Physical metallurgy of an advanced nature; consideration of solid state bonding, crystal structure, alloy constitution. Prerequisite: Metal. 509. *Mr. Ryba*

513. Advanced Chemical Metallurgy I (3) Application of thermodynamics and kinetics to the heterogeneous metallurgical processes of oxidation, reduction, smelting, and refining. Prerequisites: Chem. 452, Metal. 301, 402, 404. *Mr. Healy*

514. Dislocation Theory (3) Self and interaction energies of dislocations and other defect structures; dislocation motions and their relation to mechanical properties. *Mr. Bitler*

515. Corrosion of Metals (3) Phenomena and theories of metallic corrosion; principles of alloy selection for engineering and structural uses in corrosive environments.

516. Flow and Fracture of Solids (3) Phenomenological and theoretical treatment of flow and fracture in solids. Prerequisites: Metal. 511, 514. *Mr. Hoke*

518. Heterogeneous Equilibria at High Temperatures (2-3) Treatment of high-temperature equilibria in metal and oxide systems involving crystalline, liquid, and gas phases. Prerequisite: Metal. 513. *Mr. Muan*

519. Advanced Chemical Metallurgy II (3) Application of thermodynamics and kinetics to precipitation of nonmetallic and metallic phases from liquid and solid metals at elevated temperatures. Prerequisite: Metal. 513. *Mr. Healy*

520. Foundry Metallurgy (3) Physical-chemical considerations of the liquid state, solidification, and the solid state as applied to casting of metals and alloys. Prerequisites: Metal. 511, 513.

522. Solid-Phase Reactions in Metals (3) Mechanisms and rate determining factors in solid-phase reactions in metals; diffusion processes, nucleation theory, precipitations from solid solution, eutectoid decomposition and order-disorder phenomena. Prerequisites: Metal. 508, 511. *Mr. Bitler*

535. (E.Mch. 535) Crystal Defects and Mechanical Response (3) Mechanical responses of crystalline solids containing point, line, and interfacial defects; elastic and plastic responses. Prerequisite: Metal. 514 or E.Mch. 414.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in metallurgical studies are listed under Materials Science.*

METEOROLOGY (METEO)

Alfred K. Blackadar, *Head of the Department*
503 Deike Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Blackadar, Dutton, Hosler, and Panofsky.

Graduate Faculty: Associate Members Anthes, Hovermale, Lavoie, J. Pena, R. Pena, and Thomson.

Candidates may specialize in the study of problems in either theoretical or applied meteorology including such areas as cloud physics, various phases of dynamic meteorology including turbulence and atmospheric circulation, numerical modeling, macro- and microclimatology, synoptic meteorology, or meteorological instrumentation. The department also encourages interdisciplinary studies in such fields as agricultural meteorology, biometeorology, water resources, air pollution, and fluid mechanics.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language (French, German, or Russian). The thesis or paper option is available for the M.S. degree.

Requirements for admission include mathematics through differential equations and one year of college physics. Undergraduate study of meteorology is not required for

admission. Special programs are available to encourage the graduate study of meteorology by all students with strong backgrounds in mathematics, physics, or engineering. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

METEOROLOGY (METEO)

400. Meteorology for Teachers (3)
401. Physical Climatology for Teachers (3)
402. Biometeorology for Teachers (2)
403. Science Projects in Meteorology (1)
404. Physics of Weather Forecasting (3)
411. Introduction to Synoptic Meteorology (3)
418. Introductory Physics of the Upper Atmosphere (3)
420. Tropical Meteorology (3)
430. Introduction to Synoptic Meteorology Laboratory (3)
431. Synoptic Meteorology Laboratory I (3)
432. Synoptic Meteorology Laboratory II (2-10)
433. Advanced Synoptic Analytical Techniques (3)
434. Application of Meteorological Satellite Data to Analysis and Forecasting (3)
443. Physical Meteorology (3)
445. Hydrology for Meteorologists (3)
450. Applications of Statistics to Meteorology (3)
451. Introduction to Dynamic Meteorology (3)
452. Hydrodynamics of the Atmosphere (3)
453. Atmospheric Thermodynamics (3)
461. Theory of Meteorological Instruments (3)
472. Physical and Dynamic Climatology (3)
473. Introduction to Micrometeorology (3)

500. Meteorological Seminar (1-3) Discussion of meteorological reports and papers; scientific outlook. Prerequisites: Meteo. 411, 451.

502. Selected Topics of Advanced Meteorology (1-3 per term) Current problems in meteorology. Prerequisite: a minimum of 15 credits in meteorology.

503. Atmospheric Turbulence (3) Atmospheric diffusion, heat conduction, friction, and evaporation; statistical properties of turbulence.

505. Bioclimatology (2) Climatic phenomena in their relation to life. Prerequisite: Meteo. 472.

506. Advanced Meteorological Analysis (2-6) Physical analysis of atmospheric phenomena; synoptic analysis of weather phenomena for advanced students.

507. Dynamic Oceanography (2) Physical properties of sea water; heat balance of the oceans; theory and observations of ocean currents, waves, and tides.

508. Physics of the Upper Atmosphere (2) Temperature distribution, composition, and electrical characteristics of the upper atmosphere; theories of aurora and light of the night sky.

509. Theoretical Climatology (2) Theory of latitudinal, annual, and diurnal temperature changes; theories of climatic changes, microclimate.

510. Cloud Physics (2) Current theories on phase changes in clouds and mechanisms responsible for precipitation; techniques of cloud modification and control.

511. Cloud Dynamics (2) Study of the structure of cloud-scale motions; numerical models of cumulus clouds; thunderstorms, hailstorms, tornadoes, mesoscale organization of convection. Prerequisite: Meteo. 453.

520. Indirect Atmospheric Probing (3) Analysis and description of measurements made with radar and bistatic radio, optical and acoustic systems used for indirect atmospheric sounding. Prerequisite: Meteo. 443.

545. Snow Hydrology (2) Importance of snow in meteorology and the hydrologic cycle; snow properties, metamorphism, prediction of snowmelt runoff, and snow management potentials.

550. Atmospheric Motions (3) Fundamental properties and conservation requirements of the hydrodynamic equations; elements of advanced dynamic meteorology and applications to atmospheric dynamics. Prerequisite or concurrent: A.M. 451.

551. Atmospheric Wave Motion (2) From classical and physical hydrodynamics to the numerical prediction of wave motion in a baroclinic atmosphere. Prerequisite: Meteo. 452.

552. Advanced Atmospheric Dynamics (2) Numerical prediction models, general circulation, thermal and gravitational tides in a spherical shell, and empirical orthogonal functions of statistical forecasting. Prerequisite: Meteo. 551.

553. Energetics of Atmospheric Motion (2) Theoretical investigation of the conversions of energy in the atmosphere; maintenance of the general circulation. Prerequisite: Meteo. 452.

555. Atmospheric Diffusion (2-3) Dispersion of atmospheric contaminants; experiments, theory and practical implications for air pollution problems. Prerequisite: 3 credits of statistics.

561. Chemistry of the Atmosphere (2) Fundamental knowledge of chemical characteristics of atmospheric components and transformations, in connection with cloud microphysics, circulation, and air pollution. Prerequisite: 3 credits in chemistry.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in meteorological studies are listed under Materials Science.*

MICROBIOLOGY (MICRB)

Eugene H. Cota-Robles, *Head of the Department*
S-101 Frear Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Casida, Ceglowski, Cota-Robles, Lindstrom, Ludwig, Stone, Tershak, and Zimmerman.
Graduate Faculty: Associate Members Claus, Doty, Fung, Pootjes, and Zarkower.

Specialized areas of study in microbiology include cytology, ecology, food, genetics, immunology, physiology, virology (both animal and bacterial), and environmental

and industrial microbiology. There is opportunity for cooperative research with other departments.

The communication and foreign language requirement for the Ph.D. may be satisfied by intermediate knowledge of one foreign language (French, German, or Russian).

Prerequisites for admission are 16 credits in inorganic and organic chemistry, 6 in physics, 8 in microbiology, and mathematics through calculus. Admission may be granted with deficiencies up to 8 credits, to be made up while pursuing graduate work. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. A satisfactory score on the Graduate Record Examination is required for admission.

MICROBIOLOGY (MICRB)

400. Introductory Environmental Microbiology (4)
401. Advanced Bacteriology (4)
407. Problems in Microbiology (1-12)
410. Immunology and Serology (3)
411. Survey of Microbiology (1 per term)
413. Microbial Soil Ecology (3)
414. Food Microbiology (2-4)
415. Introduction to Animal Viruses (2-4)
416. Industrial Microbiology (4)
417. Epidemiology (2)
418. Bacterial Viruses (2-4)
470. General Microbiology for Science Teachers (4)

507. Seminar (1 per term) Reports on current fields of research.

508. Bacterial Physiology (2-4) Contributions of environment, finestructure, and metabolism to the functioning cell. Prerequisite: 6 credits of biochemistry.

510. Experimental Immunology (4) The nature of the immune response with emphasis on modern concepts and techniques. Students should have some background in immunology.

511. Special Topics in Microbiology (1-6)

512. Microbiological Methods (1-6) Practice in special laboratory techniques of modern microbiology.

516. Bacterial Genetics (2-4) Mechanisms of variation in microorganisms including mutation, adaptation, sexual recombination, transduction, and transforming factors. Prerequisite: 3 credits each in microbiology and genetics.

520. Biochemical Virology (2) Role of enzymes and nucleic acids in virus synthesis. Regulation of virus reproduction in animal and bacterial cells. Prerequisite: 6 credits of biochemistry.

529. (C.E. 579) Aquatic Microbiology (3) Ecology and physiology of microorganisms of inland waters, estuaries, and oceans; microbiology of wastewater treatment. Prerequisite: introductory microbiology.

MICROBIOLOGY (MICRB)

FRED RAPP, *Chairman of the Department*
The Milton S. Hershey Medical Center

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Member Rapp.
Graduate Faculty: Associate Members Barnes, Duff, Funk, Glaser, and Lausch.

The graduate program is oriented to the study of any aspect of microbiology, especially the general areas of bacteriology, virology, immunology, genetics, and viral oncology. Subdivisions of these disciplines are also available, and many problems in these areas are under investigation by members of the faculty.

The communication and foreign language requirement may be satisfied by one foreign language such as French, German, or Russian. Courses in creative writing or humanities can be substituted with permission.

Qualified students with undergraduate preparation in either the biological, biochemical, or physical sciences may apply. A reasonable background in biology, chemistry, and mathematics is required, although it will be possible to strengthen the background in any of these areas during the first year in the graduate program. Programs leading to advanced degrees will be tailored to the background and individual needs of the candidates.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Two letters of recommendation are required and a personal interview is desirable.

This program is offered only at The Milton S. Hershey Medical Center.

MICROBIOLOGY (MICRB)

551. MEDICAL MICROBIOLOGY (3) Principles of microbiology; viruses, rickettsia, bacteria, and fungi as agents of disease. Introduction of microbial genetics, epidemiology, and immune mechanisms.

552. MEDICAL MICROBIOLOGY LABORATORY (2) Laboratory exercises to augment Micrb. 551. Laboratory tests used to characterize microorganisms and to aid in diagnosis of disease.

553. SCIENCE OF VIROLOGY (3) Replication of viruses and effect on host, including transfer of genetic information, immunology, and oncogenic properties of viruses.

554. IMMUNOLOGY OF INFECTION (3) The nature of antigens and antibodies, humoral and cellular immune response governing histocompatability, transplantation, tolerance, and autoimmune disease.

555. MICROBIAL PHYSIOLOGY AND METABOLISM (3) Physiology and comparative biochemistry of microorganisms, especially human pathogens. Concepts of genetic regulation and balanced growth applied to cell replication.

556. MICROBIAL GENETICS (3) Genetics of microorganisms, including gene mapping, lysogeny, information transfer, and viral carcinogenesis.

557. ELECTRON MICROSCOPY (3) The application of electron microscopy to microbiology, including specimen preparation, use of the electron microscope, and photography. Prerequisite: admission to the medical or graduate program and permission of instructor.

570. Topics in Microbiology (2 per term) Lectures and seminars concerning current developments in microbiology.

571. Seminar in Microbiology (1 per term) Weekly presentations by faculty and postdoctoral and predoctoral trainees of current work in the department.

572. Literature Reports (1 per term) Weekly analysis of current literature in microbiology.

573. Selected Readings (2 per term, maximum of 6) Supervised reading program of pertinent literature in microbiology and related scientific fields.

580. Laboratory Experiments in Microbiology (2-6 per term) Laboratory exercises in microbiology, including cell culture, microscopy, radioisotope and other biochemical procedures, serology, and genetic techniques.

581. Special Projects in Microbiology (2-6 per term) Research projects carried out by graduate students under supervision of a member of the faculty.

MINERAL ECONOMICS (MN EC)

John D. Ridge, *Head of the Department*
104 Mineral Sciences Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Gordon, Harris, Ridge, and Schenck.

The program in mineral economics prepares students for careers in mineral industries management, administration, or economic analysis and planning. Students may specialize in such areas as commodity analysis (fuels, metals, or nonmetals); resource economics (mineral policy or area studies); industrial economics (administration, market research, or financial matters); geostatistical and economic analysis of exploration and exploitation problems; or operations research and statistics (resource allocation, forecasting, or decision making).

Two related but distinctly different general programs for obtaining the M.S. and Ph.D. degrees are available, the one chosen depending on the education and practical experience of the candidate. One program is for students whose background is in the mineral industries and who wish to combine their scientific training with an understanding in depth of the methods by which economics can aid in solving problems in mineral industries exploration, exploitation, and processing. Requirements for admission to this program are 24 credits in chemistry, physics, mathematics, or statistics; 12 in the earth sciences; 9 in economics, mineral economics, commerce, business administration, or industrial management; and 6 in engineering subjects.

The second program is for students whose background is in economics and whose training and experience have given them an interest in applying their economic skills to the solution of mineral industries problems. Requirements for admission to this program are 12 credits in economics, mineral economics, and business administration; 6 in geological sciences; and 9 in mathematics and statistics.

The differences between the programs followed by these two groups of students will affect every aspect of their graduate programs—thesis work, required mineral economics courses, and elective selection. In all cases, the choices among courses and the emphasis within courses taken would be determined by the background of the student, the mineral industries-based program placing equal weight on the technical and economic aspects of mineral economics and the economics-based program placing more weight on the economic than on the technical features of the problems considered.

In addition to the normal degree requirements of the Graduate School, candidates for the M.S. degree must write a thesis and defend it orally. Doctoral candidates in the mineral industries-based program must complete at least 15 credits in economics (including courses used for admission). Doctoral candidates in the economics-based program must complete at least 12 credits in the earth sciences or mineral engineering. The candidacy examination for the doctorate is entirely written, with the exception that the oral examination for the M.S. degree at The Pennsylvania State University may be used as the candidacy examination for the doctorate. If this is done, the M.S. examination will be more detailed and broader in scope than it would be for the M.S. alone. The comprehensive examination for the doctorate includes written examinations in the major program and minor fields in addition to the oral examination required by the Graduate School. The communication and foreign language requirement for the Ph.D. degree may be satisfied by competence (as defined by departmental rules) in one foreign language or mathematical statistics.

Students with deficiencies of 9 credits or fewer in either program may be admitted as degree candidates but will be required to make up such deficiencies without these credits being applicable toward the advanced degree. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

MINERAL ECONOMICS (MN EC)

400. Seminar (1)
453. Nonmetallic Minerals (3)
483. Economics of the Metals Industries (3)
484. Political Economy of Energy and the Environment (3)
486. The Energy Market (3)
490. Mineral Valuation (3)
491. Analysis of Mineral Data (3)
496. Mineral Industries Decision Making (3)

500. Advanced Readings in Mineral Economics (3) Selected readings on topics in mineral history, mineral economics research, applications of economic theory, mineral policy and law, and mineral exploration.

504. Advanced Principles of Mineral Economics (3) Minerals as capital—taxation, conservation, and land tenure; operations of mineral markets; government policy; minerals in world trade and development.

506. Advanced Studies in Mineral Commodities (3) Economic studies of selected mineral commodities and their products. Prerequisite: Mn.Ec. 491.

513. Appraisal of Mineral Resources and Analysis of Exploration Decisions (3) Mineral resource concepts; various quantitative methods for resource evaluation, including computer simulation; exploration economics and decision making within quantitative frameworks. Prerequisites: Mn.Ec. 490, 491.

593. Technical Problems in Mineral Economics (1-12) Individual research involving library, laboratory, or field work designed to provide solutions to a selected technoeconomic problem in mineral industries. Prerequisites: Mn.Ec. 500, 504.

MINERAL ENGINEERING MANAGEMENT (M E M)

THOMAS V. FALKIE
Chairman of the Committee on Mineral Engineering Management
118 Mineral Industries Building

Degree Conferred: M.Eng.

Graduate Faculty: Senior Members Aplan, Charmbury, Essenhigh, Falkie, Farouq Ali, Given, Griffiths, Harris, Healy, Hummel, Lindsay, Lovell, W. Miller, Niebel, Ridge, Rosenshine, Schenck, Slobod, Stahl, Stefanko, and Williamson.
Graduate Faculty: Associate Members Guild, Manula, Saperstein, and Slater.

This program is designed to educate engineers for advancement into executive production management positions in the mineral and heavy construction industries, in development and sales in manufacturing companies, and in consulting firms. Its aim is to provide the knowledge, skills, and attitudes needed by persons to become innovators and responsible decision-making leaders. Participants are trained to create new designs, systems, and methods, and to plan, develop, and lead mineral industry organizations.

The content of appropriate courses is based upon specific problems encountered in the mineral industries. Such courses are offered by the departments which have combined their resources to offer this interdisciplinary effort; namely, Departments of Mineral Engineering (Mining and Petroleum and Natural Gas Sections), Mineral Economics, Material Sciences, and Industrial Engineering. Courses in these areas and others may be selected by students and adapted to their individual interests.

The program emphasizes quantitative methods, principles of economics applied in mineral industries, and management.

Students are required to present a scholarly written report on a suitable project the topic of which may be suggested by industry.

For admission a bachelor's degree in one of six engineering branches of mineral industry (mining, petroleum, mineral processing, metallurgy, fuel, and ceramics) or some other closely related field (industrial, civil, geological, mechanical, or chemical engineering) is required. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exception to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

MINERAL ENGINEERING MANAGEMENT (M E M)

510. PRODUCTION AND OPERATIONS MANAGEMENT (3-9) Overall planning, design, and selection of equipment; programming and scheduling of mineral operations; statistical control of costs and production indices.

MINERAL PROCESSING (MN PR)

FRANK F. APLAN
In Charge of Graduate Programs in Mineral Processing
4 Mineral Sciences Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Aplan, Austin, and Sun.
Graduate Faculty: Associate Member Hogg.

MINERAL PROCESSING

This program is one of the options in which a graduate student in the Department of Material Sciences can receive an advanced degree. The process engineering of minerals involves treatment of raw materials to prepare them for conversion to useful products and is basic to such important industries as steel, coal, nonferrous metals, heavy chemicals, nonmetallic minerals, cement, etc. The mineral processing engineer is concerned with the separation of valuable materials from worthless rock by physical and chemical means as well as with the application of these methods to the recycle processing of used metals and minerals. He is also vitally interested in the control of air, land, and water pollution—particularly as it relates to mineral raw materials.

The training of a mineral processing engineer involves interdisciplinary combinations of chemistry, physics, the geological sciences, and engineering. This knowledge is then integrated with specialized knowledge—the creation, characterization, separation and agglomeration of particles; the surface chemistry of mineral particles; and chemical separations—to provide the basis for developing and understanding the practical means of separation of valuable material from that which is worthless.

Pollution control is an important aspect of mineral processing because of the problems of disposal of quantities of waste produced by the mining, metallurgical, cement, power, and heavy chemical industries; the volume of process water used by heavy industries; the use of mineral processing equipment and processes in most air and water pollution control methods; and the application of mineral processing methods to the recycling and reuse of metals and other valuable materials. Specifically designed courses of study are available to allow the student to emphasize pollution control in his course work and thesis research.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by reading proficiency in one foreign language. Students whose first language is English will demonstrate proficiency in German, Russian, or Japanese (or other language in which a major body of relevant technical literature exists). Where practicable, the examination will be one given or recommended by the language department. Students whose first language is not English will be required to show fluency in reading, speaking, comprehending, and writing English and may be required to demonstrate proficiency in one other language (German, Russian, or Japanese). They will normally be expected to take Spch. 115 and pass it with a grade of B or A (unless the report of the Language Testing Center for International Students indicates that this is unnecessary) and, in addition, practice in writing and discussing papers in English will be required by the study panel until a satisfactory standard is obtained. A satisfactory seminar presentation is required.

Graduates with bachelor's degrees in ceramics, chemistry, chemical engineering, fuel science, the geological sciences, mathematics, metallurgy, mining, physics, or some branch of engineering are eligible for admission. Students with deficiencies may be required to make them up concurrently with their graduate studies. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

The following courses listed elsewhere are appropriate for Mineral Processing students: Mat.Sc. 411, 420; Metal. 401, 402, 404, 420, 421, 423, 424, 425, 460.

MINERAL PROCESSING (MN PR)

*400. Special Problems (1-9)

501. Interfacial Phenomena in Mineral Systems (3) Applications of surface phenomena to mineral engineering systems. Thermodynamics of surfaces, flotation,

* May be repeated for a total of 9 credits.

adsorption of detergents, electrical double layer, flocculation, dispersion. Prerequisite: Chem. 451. *Staff*

502. Froth Flotation and Agglomeration (3) Intensive study of theory and applications of froth flotation and agglomeration. Prerequisite: Mn.Pr. 501. *Staff*

505. Physical Separations in Mineral Processing (3) Intensive study of theory and applications of gravity, magnetic, electrostatic, centrifugal and other methods of mineral processing. Prerequisite: Metal. 420. *Staff*

506. Mineral Process Plant Design (3-10) Process design and economy. Development and quantification of flow sheets. Integration of unit operations. Plant layout, equipment selection and instrumentation. Prerequisite: Metal. 420. *Staff*

507. Chemical Methods in Mineral Processing (3) Practice and theory of methods to upgrade ores by chemical treatment including roasting, solubility separations, surface phenomena, and reactions. Prerequisite: Metal. 420. *Staff*

508. Mineral Particle Systems (3) Creation, characterization, separation and agglomeration of particles. Comminution, sizing, fractionation of powders; surface area, pore size determinations. Agglomeration and balling. *Staff*

509. Particle-Fluid Dynamics (3) Movement of particles in fluids, rheology of non-Newtonian mineral suspensions, design of concentrating devices, fluidized beds, electrodynamic, magnetic separations. *Staff*

MINERALOGY AND PETROLOGY (MIN P)

Arthur L. Boettcher
In Charge of Graduate Programs in Minerology and Petrology
211 Deike Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Barnes, Bates, Boettcher, Brindley, Burnham, Dachille, Greig, Griffiths, Keith, Langmuir, Muan, Newnham, Rose, Roy, Smith, Thornton, Wickman, and White.

Graduate Faculty: Associate Members Deines, Kerrick, Ohmoto, and Suhr.

Areas of specialization include igneous, sedimentary, and metamorphic petrology, experimental petrology, mineralogy, crystallography, crystal chemistry, X-ray mineralogy, clay mineralogy, ore mineralogy, and application of statistics in the earth sciences.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages or by comprehensive knowledge of one.

The general requirements for admission are mathematics through integral calculus; chemistry through quantitative analysis; 10 credits in general physics; and 30 credits in geology, petrology, and mineralogy including microscopical petrography. Additional specific requirements must be fulfilled in most areas of specialization.

Students who have taken somewhat less than the indicated minimum of subjects may be admitted but must make up their deficiencies concurrently with their graduate studies. Students with a 2.70 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions

to the minimum 2.70 grade-point average may be made for students with special backgrounds, abilities, and interests.

The nonthesis option is available for the M.S. degree.

MINERALOGY (MIN)

400. (Cer.Sc. 400) Nonmetallic Crystal Chemistry (2-3)
402. Mineralogy and Petrology for Teachers (3) *Mr. Thornton*
411. (Mat.Sc. 411) Instrumental Techniques Applied to Materials and Mineral Science Problems (1-5)
Unit A. X-Ray Diffraction
Unit B. Electron Microscopy *Mr. Thrower*
Unit C. Spectroscopy *Mr. Suhr*
Unit D. Electron Probe Analysis *Mr. E. White*
Unit E. Scanning Electron Microscopy *Mr. E. White*
421. (Mat.Sc. 421) X-ray Diffraction (3) *Mr. Smith*
431. (Mat.Sc. 431) Instrumentation for Physical Measurement and Control (3) *Mr. Vastola*
450. Volcanology (3) *Mr. Thornton*
463. Optical Mineralogy (3) *Mr. Kerrick*
483. Petrology (3) *Mr. Thornton*
484. Petrology and Geochemistry of Sediments (3) *Messrs. Langmuir and Williams*
490. Petrographic Problems (1) *Mr. Thornton*

500. Optical Crystallography of Materials (3) Optical methods, microscopic techniques, and measurement of optical constants of crystals; theory and application of the universal stage. Prerequisite: Min. 463. *Mr. Kerrick*

*510. Metamorphic Petrology (2-6) Detailed review of chemical, mineralogical, and structural changes that take place during metamorphism. Prerequisites: Min. 483, 484. *Mr. Kerrick*

513. Scientific Method in Geoscience (3) Problem formulation, sampling designs, selection of variates, and comparison of techniques for analysis of aggregates. *Mr. Griffiths*

514. Statistical and Electronic Data Processing Procedures for Geoscience (3) Statistical analysis of experimental data using univariate and bivariate procedures. *Mr. Griffiths*

515. Ore Microscopy (3) Optical and hardness measurements and phase equilibria as used in identification and interpretation of textures of ore minerals. *Mr. Barnes*

525. Igneous Petrology (2-6) Origin, distribution, and composition of igneous rocks. Prerequisites: Gchem. 513; Min. 483, 484, 500, 527. *Messrs. Burnham and Thornton*

526. Problem Solving in Geoscience (3) Multivariate statistical analysis, decision making, operations research, and systems analysis in geoscience. *Mr. Griffiths*

527. Mineralogy I—Silicates (3) Detailed study of the crystal structures and crystal chemistry of the silicate minerals. *Mr. Smith*

528. Mineralogy II—Nonsilicates (3) Detailed study of the crystal structures and crystal chemistry of the nonsilicate minerals. *Mr. Smith*

*Credits to be arranged, 2-4 per term.

530. (Cer.Sc. 530) Structure, Properties, and Occurrence of Clay Minerals (2-5) Structure analysis and identification of clay minerals; mineral transformations and behavior; occurrence, genesis, and petrography of fine-grained sediments. *Mr. Brindley*

531. (Mat.Sc. 531) Electron Transmission Microscopy in the Materials and Mineral Sciences (3) Discussion of electron image contrast theory as a tool for study of atomic substructures in the materials and mineral sciences. *Mr. Thrower*

532. (Mat.Sc. 532) Structure Analysis (2) Crystal structure determination methods: space groups, structure factors, heavy atoms and isomorphous replacement, Fourier synthesis, Patterson maps, inequalities, refinement techniques. Prerequisite: Mat.Sc. (Min.) 421. *Messrs. Newnham and Smith*

533. (Mat.Sc. 533) Single Crystal Methods (2) Experimental techniques in crystal structure determination: crystal selection, space group determination, measurement of intensities, analysis of data. Prerequisite: Mat.Sc. 421 or Min. 421. *Mr. Ryba*

534. (Mat.Sc. 534) Diffraction by Crystals (2) Interaction of radiation with matter: coherent and incoherent scattering, extinction, fluorescent, polarization. Prerequisite: Min. (Mat.Sc.) 421. *Mr. McKinstry*

535. (Mat.Sc. 535) Geometrical Crystallography (3) Derivation of lattices, types, point groups and space groups with applications. *Mr. Smith*

538. (Mat.Sc. 538) Electron Beam Analysis of Solids via X-ray and Electron Emission (3) Theory of phenomena occurring in electron-bombarded solids and their applications to analysis of solids. *Mr. E. White*

540. Meteoritics (2) Mineralogy, petrology, and chemistry of meteorites; theories of their origin and formation. Prerequisite: Min. 483 or 501. *Mr. Wickman*

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in mineralogical studies are listed under Materials Science.*

MINING ENGINEERING (MNG E)

Thomas V. Falkie, *Head of the Department of Mineral Engineering*
118 Mineral Industries Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Charmbury, Falkie, Hardy, Lovell, Stefanko, and Voight.

Graduate Faculty: Associate Members Manula and Saperstein.

Areas of specialization which may be followed in research and course work include mine property valuation and economics of mining engineering (ore estimation, cost analysis and control, budgeting); mechanization and mine plant (unit operations, materials handling, continuous mining, power supply); development and exploitation methods (mine planning and layout, design of systems); mine management, production engineering (work and methods analysis, operations analysis); operations research, environmental control and health and safety (gas and dust technology, ventilation, air conditioning, hygiene, illumination, noise, safety, mine drainage, land reclamation, waste disposal); and rock mechanics (stress analysis, roof and ground control, penetration, fragmentation, subsidence).

Students who desire to obtain the Master of Engineering degree in mining engineering must take a minimum of 30 credits (including at least 12 credits at the 500

level) of appropriate courses in the major area and elective courses. A scholarly written report is also required. Programs of study are available in general mining engineering, rock mechanics, mine operations, research systems engineering, internal or external mine environmental control, mine health and safety; and emphasis can be given to any of the areas listed above.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by completion of courses in two languages or by completion of courses in one language and 6 credits of computer science. A thesis is required for the M.S. degree.

A bachelor's degree in mining engineering or a related engineering field is required for admission. Students may be required to make up deficiencies in their area of specialization. Certain basic related courses outside the department may be approved as part of the major. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

MINING (MNG)

400. Mining and Our Environment (3)
402. Mine Plant Design (3)
410. Mining Engineering Analysis (3)
411. Mine Systems Engineering (3)
422. Mine Ventilation and Air Conditioning (3)
431. Rock Mechanics (3)
451. Advanced Mining Engineeering (1-3)

513. Mine Cost Analysis (3) Nature of mining costs, their analysis and control: depreciation and depletion, capital and operating costs, budgets, records.

514. Mine Operations Analysis (3) Application of operations research techniques in determining optimal design and operating policies for mine management. Prerequisite: Mng. 411.

515. Mine Systems Simulation (3) Principles and practices of probabilistic and deterministic simulation in the analysis of operating systems related to mills and mines. Prerequisites: Mng. 411, Cmp.Sc. 401.

531. Rheological and Strength Characteristics of Rocks (3) Properties of rocks and their determination; failure theories; brittle to ductile transition; rheological behavior. Prerequisite: Mng. 431.

532. Special Topics in Rock Mechanics (1-3) Behavior of rock under static loading; underground stress instrumentation; experimental stress analysis; design of mine openings; theories of subsidence.

533. Post-Yield Mechanics of Rock (3) Theory of inelastic, time-independent rock behavior; selected applications to drilling, blasting, mine opening, pit slopes, and ore passes. Prerequisite: Mng. 431.

542. Theory of Rock Fragmentation (3) Behavior of rock under dynamic loads intended to fragment; physical chemistry of explosives; detonation; theory of blasting; design of drill rounds. Prerequisites: E.Mch. 13, Mng. 30, Phys. 203.

543. Strata Control Engineering (3) Theoretical considerations; convergence, abutments, subsidence; rockbursts; underground support systems; design of mine openings. Prerequisite: Mng. 431.

545. Rock Mechanics Instrumentation (3) Strain gage circuitry, transducers, electro-hydraulic servo installations, and integrated strain and force measuring systems as applied to rock mechanics. Prerequisite: Mng. 431.

580. Mining Engineering Research (1-3 per term) Supervised research on a specific problem involved in mining science or technology.

MUSIC (MUSIC)

Robert W. Baisley, *Head of the Department*
232 Music Building

Degrees Conferred: M.A., M.F.A.

Graduate Faculty: Senior Member Brinsmaid.
Graduate Faculty: Associate Member Baisley.

The Master of Arts degree program is designed to provide a wide range of studies in music. The student may emphasize one of the following areas, or may elect a program including work in all of them: theory, performance, history, and composition. Admission requires completion of a recognized music major. A thesis or paper is optional to all M.A. candidates in the program.

The Master of Fine Arts degree program is planned to provide professional emphasis. Students will specialize in either performance or composition. In addition to credit requirements, admission to the program is contingent upon department certification of the candidate's competence. According to the area of specialization, auditions or submission of manuscripts are required. Arrangements for this can be made by the student with the department. While 48 credits are listed as a minimum requirement, it should be noted that the amount of course work necessary may exceed the minimum according to the needs and background of the student involved.

Students who lack the recommended upper-class courses in music may be required to take additional course work without receiving graduate credit.

The department sponsors musical activities, and candidates for both degrees are required to participate in positions of responsibility.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

MUSIC (MUSIC)

410. Music of the Twentieth Century (3)
412. Music of the Baroque Period (3)
413. Music of the Middle Ages (3)
414. Music of the Renaissance (3)
417. Music of the Classical Period (3)
418. Music of the Romantic Period (3)
*‡429. Vocal Style (3) Fee $80.
433. The Singing Voice (3)
455. Form and Analysis (2)

* Course may be scheduled only by conference with the head of the department.
‡ May be repeated for a total of 18 credits.

457. Composition (2)
459. Orchestration and Arranging (3)
465. Form and Analysis (2)
466. Advanced Conducting (2)
467. Opera Workshop (1-6)
468. Advanced Chamber Music (1-6)

*‡501. Advanced Harpsichord (3) Instruction in harpsichord playing; preparation for recital performance. Fee $100.

*‡503. Advanced Orchestral Instruments (3) Study, repertoire building, and recital performance. Fee $80.

*‡511. Advanced Piano (3) Piano literature of all periods for public performance. Fee $80.

*‡520. Voice (3) Study, repertoire building, and recital performance. Fee $80.

*‡531. Advanced Organ (3) Study, repertoire building, and recital performance. Prerequisite: 4 credits of Music 31 and/or 38. Fee $100.

543. Modern Harmony (3) Harmonic writing based on twentieth century practices with attention to traditional idioms that serve as foundation.

545. Counterpoint (3) Principals of contrapuntal techniques from the sixteenth century to the present. Required of all M.F.A. candidates in composition.

*‡558. Free Composition (3) Composition: vocal and instrumental, standard or modern idioms.

†560. Orchestral and Choral Conducting (3) Supervised conducting in selected performance situations, rehearsal techniques and comprehensive score analysis.

571. Performance Practices (3) Analysis and performance of music of various periods based on manuscripts, documents, and other source materials.

580. Studies in Orchestral Literature (3) Selected studies in orchestral literature from the seventeenth century to the present.

581. Studies in Chamber Music Literature (3) Selected studies in chamber music of all types from the seventeenth century to the present.

582. Studies in Keyboard Literature (3) The literature of major keyboard instruments from the sixteenth century to the present.

583. Studies in Choral Literature (3) Selected studies in choral literature of all types from the Renaissance to the present.

584. Studies in Operatic Literature (3) Studies in the development of the opera from 1600 to the present treating both libretto and music.

589. Music Seminar (1-6) Seminar in the history, art, and science of music, with readings, discussion, and performance.

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* Course may be scheduled only by conference with the head of the department.
‡ May be repeated for a total of 18 credits.
† May be repeated for a total of 9 credits.

MUSIC EDUCATION (MU ED)

FRANCES M. ANDREWS, *Head of the Department*
264 Chambers Building

Degrees Conferred: D.Ed., M.Ed.

Graduate Faculty: Senior Members Andrews, Deihl, and Dunlop.
Graduate Faculty: Associate Members Boyle and Campbell.

Graduate programs in music education prepare students for careers in public school music teaching, music supervision, college teaching, administration, or research. It is possible to include study in a number of these areas in the M.Ed. or D.Ed. programs.

Completion of a recognized music education major, or program leading to teaching certification in music, is a prerequisite for admission to the M.Ed. or D.Ed. programs.

Applicants for the master's program who present a 2.50 junior-senior average and two satisfactory professional references will be considered for admission to the Department of Music Education, provided they have appropriate course backgrounds and musical proficiency.

Admission to the doctoral program requires: a junior-senior minimum average of "B"; approximately half of any graduate credits of "A" quality; interview prior to admission; submission of satisfactory score on Miller Analogies Tests; five recommendations attesting to scholarship, musicianship, and ability to do independent study; and a minimum of two years of successful teaching experience in public or private schools.

The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum grade-point average may be made for students with special backgrounds, abilities, and interests.

MUSIC EDUCATION (MU ED)

415. WORKSHOP IN SELECTED MUSIC EDUCATION STUDIES (1-6)
446. THE ELEMENTARY MUSIC SPECIALIST (3)
468. THE TEACHING OF PIANO (3)
469. BAND AND ORCHESTRA TECHNIQUE (3)
471. TEACHING MARCHING BAND (3)
472. WIND INSTRUMENT MATERIALS (3)
473. PSYCHOLOGICAL FOUNDATIONS OF MUSICAL BEHAVIOR (3)
474. TESTS AND MEASUREMENTS IN MUSIC (3)
480. CHORAL PROGRAM IN THE SECONDARY SCHOOL (3)
487. CHILDREN'S SONGS AND RECORDS (3)

500. MUSIC EDUCATION SEMINAR (3-6) Problems of various phases of music education, both instrumental and vocal; research and literature dealing with these problems.

501. PROBLEMS AND PROJECTS IN MUSIC EDUCATION (1-6) Independent work on special topics of music education pertinent to the development of curricula, methods, and materials in music education. Prerequisite: 12 graduate credits in education (including music education).

525. PROSEMINAR: GRADUATE STUDY IN MUSIC EDUCATION (1-3) Bibliography; location and evaluation of reference materials; organization, form, style in preparing music education research reports and other papers.

555. RESEARCH METHODS IN MUSIC EDUCATION (3-6) Research methods and designs for problems in music education; techniques for studying cognitive, affective, and psychomotor responses to musical stimuli. Prerequisites: Mu.Ed. 525, Ed.Psy. 406 or 407, 475.

569. Present-Day Trends in Instrumental Music (3-6) New methods and materials for band, orchestra, and ensembles.

570. Choral Technique (3-6) Analysis and evaluation of choral materials appropriate for secondary school chorus; program building; practical rehearsal and conducting techniques. Prerequisite: 6 credits of vocal study.

572. Instrumental Pedagogy (3-6) Research problems in band and orchestra. Prerequisite: Mu.Ed. 54 or practical experience.

573. The Materials of Appreciation (3) Examination of written and recorded materials and appropriate techniques for developing appreciation of music, grades one through twelve.

574. Present-Day Trends in Music Education (3-6) Present-day music education materials and methods (elementary and secondary levels) in relation to modern educational philosophy; emphasis on practical problems presented by members of the class. Prerequisites: Mu.Ed. 48, teaching experience.

575. The Junior High School Music Curriculum (3) Instructional materials, procedures, curricular and extracurricular activities, integration with other subjects.

576. Music Supervision (3) Current educational procedures in training music supervisors.

581. Contemporary Music Education (3) Prerequisite: 20 credits at the graduate level including Mu.Ed. 500.

582. Theory and Projects in Musical Learning (3-6) Experimentation and self-instructional techniques involved in musical learning projects. Prerequisite: Inst.M. 435.

591. Internship in Music Performance Techniques (1-6) Internship in selected school or music performance situations other than those in the district where the graduate student is employed.

594. Pedagogy of Music Theory, Reading, and Ear Training (3) Instructional theory and materials basic to teaching music theory, reading, and ear training. Musical instruments, audio-visual devices as aids. Prerequisite: 12 credits in music theory and/or harmony.

NUCLEAR ENGINEERING (NUC E)

Warren F. Witzig, *Head of the Department*
231 Sackett Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Diethorn, Foderaro, Jacobs, Kenney, Klevans, Levine, Palladino, Remick, Schultz, and Witzig.

Graduate Faculty: Associate Members D'Ardenne, Jester, and Robinson.

Programs of study are individually tailored, and engineering is emphasized through the study of reactor principles—computational methods, transport theory, and nuclear design; plasma principles—waves, analysis, and fusion laboratory; shielding—Monte Carlo methods and two-body kinematics; reactor systems design—thermal, mechanical, and control; reactor fuels—configuration, radiation effects, and fuel cycle management; isotope utilization—activation analysis, chemical processes including copo-

lymerization and nuclear medicine; plowshare applications; safety analysis—reactor siting, engineered safeguards, and environmental effects. The department offers three degrees at the master's level: M.Eng., M.S. with paper, and M.S. with thesis. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language and proficiency in English.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

NUCLEAR ENGINEERING (NUC E)

400. Nuclear Engineering Special Topics (1-12)
401. Introduction to Nuclear Engineering (3)
402. Introductory Reactor Analysis II (3)
410-411. Nuclear Reactor Theory (3 each)
415. Radionuclear Applications (3)
420. Radiological Safety (3)
428. Radioactive Waste Control (3)
430. Design Principles of Reactor Systems (3)
431. Synthesis of Nuclear Systems (3)
440-441. Nuclear Engineering Laboratory (3 each)
490. (E.E. 490) Introduction to Plasma Theory (3)

501. Reactor Engineering (3) Reactor controls, shielding of nuclear reactors, stress analysis of reactor materials, power cycle analysis, breeding, and advanced design considerations. Prerequisite or concurrent: Nuc.E. 411.

502. Reactor Engineering Laboratory (1-5) Reactor experiments devised to acquaint the student with reactor technology. Prerequisite or concurrent: Nuc.E. 411.

503. Thermonuclear Engineering (3) Binary fusion reactions; microscopic and macroscopic phenomena in a completely ionized gas; electromagnetic confinement; design, operation, and diagnostics of experiments. Prerequisite: Math. 452.

505. Reactor Instrumentation and Control (3) Neutron-detecting instruments and circuits; in-core power instrumentation; reactor control principles; control mechanisms; operational control problems. Prerequisite: Nuc.E. 411.

506. Two-Body Kinematics (3) Conservation laws of classical and quantum mechanics and their application to interactions between two bodies. Prerequisite: Math. 72.

507. Interaction of Radiations with Matter (3) Theory of the processes by which gamma rays, neutrons, and charged particles interact with electrons, atoms, and nuclei. Prerequisite: Nuc.E. 506.

508. Radiation Shielding (2) Radiation sources in reactor systems; attenuation of gamma rays and neutrons; deep penetration theories; Monte Carlo methods. Prerequisite: Nuc.E. 507.

509. Radiation Damage in Solids (2) Production of defects by high energy particles; nature of defects; diffusion and annealing in solids; macro property changes. Prerequisite: Nuc.E. 507.

511. Nuclear Reactor Materials (3) Philosophy, selection, technology, use, economics, and performance of materials of major interest in nuclear power reactors today. Prerequisite: Nuc.E. 411.

520. Reactor Analysis (3) Physical principles and mathematical methods of reactor analysis. Prerequisite: Nuc.E. 410.

521-522. Neutron Transport Theory (3 each) Derivation of Boltzmann equation for neutron transport; techniques of approximate and exact solution for the monoenergetic and spectrum regenerating cases. Prerequisite: Nuc.E. 410 or Phys. 406.

525. Nonlinear Reactor Kinetics (3) Intrinsic response of reactors to extreme reactivity insertions, mathematical models, physics of feedback coefficients, analysis of behavior of burst reactors. Prerequisite: Nuc.E. 411.

540. (E.E. 540) Theory of Plasma Waves (3) Solutions of the Boltzmann equation; waves in bounded and unbounded plasmas; radiation and scattering from plasmas. Prerequisite: Nuc.E. 490.

550. Special Topics in Nuclear Engineering (1-12) Organized studies in nuclear engineering with or without associated experimental work. Prerequisites: Math. 72, Phys. 406.

591. (E.E. 591) Plasma Theory (3) Advanced topics in kinetic theory, fluctuation theory, microinstability, and turbulence. Prerequisite: Nuc.E. 590.

NUTRITION (NUTR)

Helen A. Guthrie
In Charge of Graduate Programs in Nutrition
202 Human Development Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.; M.S. in Nutrition in Public Health.

Graduate Faculty: Senior Members Guthrie and Pike.

Graduate Faculty: Associate Members Brinkman and Wright.

Graduate programs in nutrition prepare students for careers in college teaching, research, industry, and government. The program in nutrition in public health prepares the student for work in public health agencies and community nutrition.

To satisfy the communication and foreign language requirement for the Ph.D. degree students are expected to demonstrate competence in technical writing (Engl. 418) and spoken English.

For admission to a graduate program in nutrition, a student must have completed at least 6 credits in inorganic and organic chemistry, 3 each in biochemistry, microbiology, and physiology, 4 in other physical and biological sciences, and 8 in foods and/or nutrition. For admission to the program in nutrition in public health, an additional 12 credits in social sciences are required.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Students with up to 9 credits of deficiency may also be admitted. Any deficiencies must be completed with a grade of B within two terms.

NUTRITION (NUTR)

400. Special Problems in Foods and Nutrition (1-3)
420. Experimental Cookery (3)
421. Cultural and Aesthetic Aspects of Food (3)

422. Scientific Principles of Food Preparation (3)
452. Nutritional Aspects of Disease (3)
453. Diet Therapy (2)
456. Nutrition in the Community (3)
457. Principles of Nutrition (3)
458. Applied Nutrition (2)
459. Advanced Nutrition (3)
490. Foods and Nutrition Seminar (1)

520. Readings in Applied Nutrition (2) Critical review and reports of literature on selected topics in applied nutrition.

521. Topics in Nutrition (1-6) Intensive study of current developments on selected topics in nutrition.

522. Advanced Experimental Foods (3) Experimental methods used in measuring the quality of foods; specific problems in food preparation.

530. Problems in Foods and Nutrition (1-6)

550. Readings in Nutrition (3) Readings and reports of selected topics in nutrition.

551. Seminar in Nutrition (1-6) Selected topics and recent advances in nutrition.

552. Nutrition in Disease (3) Physiological and biochemical problems in metabolic diseases and the nutritional aspects of therapy.

555. Field Work in Nutrition (2-4) Field problems planned to meet the needs of individual students. Hours and problems to be arranged.

556. The Survey Method in Foods and Nutrition (2) Study of survey techniques as a tool in the assay of food adequacy and nutritional status.

557. Interrelationships of Nutrients (2) Interrelationships of nutrients in the metabolic processes; their significance as applied to nutrition.

PETROLEUM AND NATURAL GAS ENGINEERING (PNG E)

C. Drew Stahl
Head of the Section of Petroleum and Natural Gas
25 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Bissey, Burcik, Farouq Ali, Slobod, and Stahl.
Graduate Faculty: Associate Member Slater.

Areas of specialization include experimental and theoretical studies of water flooding and the newer methods for displacing oil from porous media, methods for calculating reservoir performance, scaled laboratory studies of reservoir phenomena, and drilling and well completion problems.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Students who expect to enter graduate study in this program with a degree in another major should present 6 credits in geology, 15 in engineering science, and

credit for mathematics through integral calculus. A limited number of deficiencies may be made up after admission. Certain closely related courses outside the department may be counted as petroleum and natural gas credits toward the degree.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

PETROLEUM AND NATURAL GAS (P N G)

400. Thesis (1-6)
410. Applied Reservoir Engineering (3)
420. Applied Reservoir Analysis (3)
421. Reservoir Engineering (3)
450. Drilling Design and Production Engineering (3)
475. Petroleum Engineering Design (3)
480. Production Process Engineering (3)
481. Natural Gas and Gasoline Plants (2)
485. Engineering in Secondary Recovery (3)
493. Engineering Evaluation of Oil and Gas Properties (3)

510. Solution of the Partial Differential Equations of Flow in Porous Media (3) The application of mathematical techniques to solve the partial differential equations of steady and unsteady state flow in porous media. Prerequisite: Math. 405.

511. Numerical Solution of the Partial Differential Equations of Flow in Porous Media (3) Differencing schemes for the partial differential equations of single-phase flow; application to flow of gas and mixing in porous media.

512. Numerical Reservoir Simulation (3-6) Mathematical analysis of complex reservoir behavior and combination drives; numerical methods for the solution of behavior equations; recent developments. Prerequisite: P.N.G. 510.

514. Optimization of Petroleum Recovery Processes (3) Optimum search methods, linear programming, nonlinear programming, dynamic programming, application to waterflooding, depletion drive, steam injection, gas cycling, miscible displacement. Prerequisite: P.N.G. 410.

515. Advanced Oil Recovery Techniques (3) Advanced oil recovery techniques including water-flooding, in-situ combustion, steam injection, hot-water injection, and miscible-phase displacement.

519. Design of Thermal Recovery Projects (3) Suitability of reservoirs for thermal oil recovery; case histories; design of in-situ combustion and steamfloods; thermal stimulation; shale oil recovery. Prerequisite: P.N.G. 515.

520. Phase Relations in Reservoir Engineering (3) Phase relations as applied to condensate and retrograde condensate reservoirs and to other problems in petroleum production.

530. Natural Gas Engineering (1-3) Flow in producing or storage reservoirs; gas well testing; transmission systems; storage cycle; current developments. Prerequisite: P.N.G. 481.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in petroleum and natural gas studies are listed under Materials Science.*

PHARMACOLOGY (PHARM)

ELLIOT S. VESELL, *Chairman of the Department*
The Milton S. Hershey Medical Center

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Fritz, Greene, and Vesell.
Graduate Faculty: Associate Members Connor, Hill, Passananti, Severs, and Smith.

The department offers opportunities for research and courses in drug metabolism, endocrine pharmacology, neuropharmacology, cardiovascular pharmacology, clinical pharmacology, and general pharmacology. Emphasis is placed on molecular and physiological mechanisms by which drugs act in the body and by which the body transforms drugs.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign languages.

A bachelor's degree reflecting a reasonable background in zoology or biology, mathematics, and chemistry is required; reading knowledge of one or two foreign languages is recommended, but not required. Applicants must provide complete transcripts and two letters of recommendation. Scores from the Graduate Record Examination and a personal interview are desirable. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

This program is offered only at The Milton S. Hershey Medical Center.

PHARMACOLOGY (PHARM)

501. PHARMACOLOGY (3) Lectures, discussions, and laboratory study of the mechanism of drug action in biological systems.

502. PHARMACOLOGY (4) Continuation of Pharm. 501.

504. DRUG METABOLISM (3) Study of chemical transformation of drugs within animal cells and drug-metabolizing enzymes present in liver microsomes performing this function. Prerequisite: Pharm. 501.

506. PHARMACOLOGY OF ENDOCRINE ORGANS (3) Current concepts of interaction of endocrine tissue with endogenous compounds and pharmacological agents. Prerequisite: Pharm. 501.

507. PHARMACOLOGY OF PSYCHOACTIVE DRUGS (3) Current theories of mental diseases and pharmacological agents used to treat them will be covered. Prerequisite: Pharm. 501.

508. PHARMACOLOGY OF BIOLOGICALLY ACTIVE MONAMINES (3) The role of monamines in body function and alteration of their activity by drugs will be discussed. Prerequisite: Pharm. 501.

509. DEVELOPMENT OF THERAPEUTIC AGENTS (3) This course will deal with stages of drug development ranging from laboratory studies to routine human consumption.

512. CLINICAL PHARMACOLOGY (3) Drug therapy of cardiovascular, renal, and neural diseases will be discussed.

515. Human Genetics (2) Seminar-type presentations by students and staff on fundamental problems and current topics in human genetics.

520. Principles of Drug Action (3) Detailed analysis of basic parameters governing drug actions.

540. Pharmacogenetics (3) Study of human responses to individual drugs.

550. Autonomic Nervous System Pharmacology (3) Study of drugs concerned with and acting on the sympathetic and parasympathetic nervous systems.

560. Pharmacology Seminar (1-3 per term) Student and staff seminar designed to familiarize medical and graduate students with current research developments in the field.

570. Special Topics (1-6) Introduction of students to the research laboratory and the scholarly pursuits of members of the staff.

590. Research (1-12) Individualized research conducted by students in departmental laboratories.

PHILOSOPHY (PHIL)

Carl R. Hausman, *Head of the Department*
247 Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty: Senior Members Anderson, Ford, Gotshalk, Hausman, Johnstone, Kockelmans, Lingis, and Rosen.

Graduate Faculty: Associate Members Flay, Kennington, Price, Tsugawa, Vaught, and Verene.

A thorough grounding in the history of philosophy is desirable for all students. Specialization is possible in areas (such as aesthetics, metaphysics, ethics, social philosophy, logic, and history and philosophy of science); in movements of thought (such as rationalism, empiricism, idealism, phenomenology, and existentialism); or in any of the major figures in the history of western philosophy. Specialization is also possible in a joint program with the Department of Mathematics in logic and the foundations of mathematics. Undergraduate preparation to the extent of a strong minor is advisable. The department may waive the requirement of a thesis for an M.A. candidate.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages or by comprehensive knowledge of one.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

PHILOSOPHY (PHIL)

406. Medieval Philosophy (3)
408. Studies in Social and Political Philosophy (3)
410. Studies in Greek Philosophy (3-6)
411. Studies in Modern Philosophy (3-6)

412. Studies in Contemporary Philosophy (3-6)
413. Philosophy of Literature (3)
414. Aesthetic Theory (3)
417. Nineteenth Century Philosophy (3-6)
419. Philosophical Backgrounds of American Thought (3)
420. Philosophy of History (3)
421. Classics of Scientific Methods (3)
424. Studies in Philosophy of Religion (3)
426. Metaphysics (3-6)
427. Advanced Ethics (3)
428. (Math. 428) Logical Theory (3)
429. Semantics: Philosophy of Language and Symbolism (3)
430. Philosophical Problems (1-9)
435. Religion and Science (3)

500. Ethics: Historical and Systematic (2-6) Critical study of some phase of ethical theory, or of some period of the history of ethics.

504. Social and Political Philosophy (3-6) Critical study of basic problems in their historical and functional setting.

505. Philosophy of Western Religion (3-6) The consideration of contemporary western religious concepts in terms of their Graeco-Judean traditions.

506. Seminar in Ancient Philosophy (3-6) Study of one or more important men or movements in ancient philosophy.

507. Seminar in Medieval Philosophy (3-6) Study of one or more important men or movements in medieval philosophy.

508. Seminar in Modern Philosophy (3-6) Men and movements in philosophy from the Renaissance through the nineteenth century.

509. Seminar in Contemporary Philosophy (3-6) Men and movements in twentieth century philosophy.

511. Principles of Experimental Inference (3-6) Science as controlled inquiry; types of scientific procedures in formal, physical, and sociocultural science.

512. Advanced Topics in Philosophy of Science (3-6) Crucial problems in the theory of science and scientific method.

514. Seminar in Nineteenth Century Philosophy (3-6) Study of a philosopher or philosophical movement of the nineteenth century.

515. Philosophical Method (3-6) Methods proposed by classical and contemporary thinkers for reaching philosophical conclusions: deductive, inductive, dialectical, pragmatic, intuitive.

516. Seminar in Aesthetics (3-6) Problems and theories in the nature of art.

526. Seminar in Metaphysics (3-6) Formulation and analysis of metaphysical problems in the various fields of philosophy.

530. Philosophy Research Seminar (1-12) Study of selected philosophical problems with an emphasis on techniques of philosophical research.

550. (Math. 550) Foundations of Mathematical Logic (3) The nature of logical basis of mathematics; critical examination and development of the basic parts of logical calculus. Prerequisite: Math. 480 or Phil. 428.

554. (Math. 554) Logic and Metamathematics I (3) Completeness, Löwenheim-Skolem, Herbrand, and compactness theorems; first-order theories; categoricity, elimination of descriptions; decidability; algebraic and geometric applications. Prerequisite: Phil. 428.

556. (Math. 556) Recursion Theory (3) Recursive functions; normal form, enumeration and separation theorems; partial recursive functions; recursion theorems; special recursive functions; alternate formulations; related topics. Prerequisite: Phil. 428.

557. (Math. 557) Logic and Metamathematics II (3) Arithmetization; Gödel and Tarski incompleteness theorems; undecidability results; Gentzen-type systems and consistency results. Prerequisite: Phil. 428.

PHYSICAL EDUCATION (PH ED)

Betty van der Smissen
Associate Dean for Graduate Study and Research
275 Recreation Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Buskirk, Gross, Harnett, Hunt, Mendez, Nelson, Rhoades, and van der Smissen.

Graduate Faculty: Associate Members Gahagen, Gray, Harris, Kollias, Lucas, Lundegren, Magnusson, Morehouse, Nicholas, and Stoedefalke.

Areas of specialization include (1) adapted physical education; (2) administration-supervision (methods and materials, curriculum construction, intramurals, and interscholastics); (3) biomechanics (applied anatomy and kinesiology); (4) health education; (5) history of sport and physical education; (6) measurement and test construction; (7) motor learning; (8) physiology of exercise (physical conditioning, physical fitness, and performance stress); (9) psychosocial foundations of physical activity; and (10) recreation and parks.

Admission to the M.S. program requires a major in physical education or its equivalent in comparable course work. Especially desirable is a concentration on the physical, biological, behavioral, or social sciences, depending upon the intended areas of specialization. Admission to the M.Ed. program requires a minimum of 18 credits in health and physical education plus 18 credits in education and educational psychology combined, including practice teaching. A year or more of field experience is recommended.

Admission to doctoral study requires the master's degree or its equivalent, demonstrated research ability in the form of a thesis or published research, and acceptable performance on the Aptitude Test of the Graduate Record Examination or other specified tests. A student who has earned a master's degree in recreation and parks and meets the above requirements may enter a doctoral program in physical education with specialization in recreation and parks. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Students wth a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests.

See also Recreation and Parks.

HEALTH EDUCATION (HL ED)

411. Principles and Methods of Teaching Safety Education (3)
456. Advanced Techniques in School Community Health Education (3)
496. Special Projects (1-6)

501. Health Implications in the Growth and Development of School Children (3) Child growth and development emphasis for teachers; medical inspection and examination; preschool program; early habit formations; behavior problems; cooperation of parents, teachers, and children. Prerequisite: Hl.Ed. 215.

503. Health Implications in Maturity and Aging (3) Changes in the human body in maturity and aging. Theories and mechanisms of physiologic aging with implications for health education. Prerequisite: Hl.Ed. 501.

PHYSICAL EDUCATION (PH ED)

400. Adaptive Physical Education (3)
420. Psychosocial Dimensions of Physical Activity (3)
450. Current Research Literature in Physical Education (3)
452. Analysis of Physical Education Activities for the Elementary School (3)
455. Statistical Methods in Health, Physical Education, and Recreation (3)
456. Physical Fitness Appraisal (3)
460. Methods and Principles of Athletic Coaching (3)
462. Administration of Athletic Programs (2)
470. History and Theory of Dance in Education (2)
480. Advanced Anatomy and Physiology, Applied (3)
483. Principles of Body Mechanics (3)
484. Kinesiology (3)
489. Intramural Athletics (3)
490. Introduction to Tests and Measurements in Health and Physical Education (3)
491. Organization and Administration of Health and Physical Education in Schools (3)
495. History of Sport in American Society (3)
496. Special Projects (1-6)
497. Sport in Antiquity (3)

500. (Rc.Pk. 500) Individual Study and Research Projects (1-10) Prerequisite: Ph.Ed. 530.

520. Psychology of Sport (3) Study of man's psychological behavior in sport and physical activity; development of somatopsychic theory of physical activity. Prerequisite: 6 credits in psychology.

522. Sport in Society (3) Examination of the cultural phenomenon of sport; social behavior in sport; institution of sport and relationship with other social institutions. Prerequisite: 3 credits in sociology.

530. (Rc.Pk. 530) Research Techniques in Health and Physical Education and Recreation (3)

531. Research in Health and Physical Education and Recreation (3) Prerequisite: Ph.Ed. 530.

532. Tests and Measurements in Physical Education (3) Critical study of tests and measurements available in physical education; methods of constructing and evaluating new tests and measurements. Prerequisite: Ph.Ed. 490.

534. Studies in Curriculum Construction in Physical Education (3) Principles and methods of curriculum building in physical education; different psychological and educational points of view, organizing a course of study committee, making units of instruction.

535. Modern Foreign Systems of Sport and Physical Education (3) Comparative analysis of national and local programs and systems of physical education in foreign countries. Prerequisites: Ph.Ed. 534, 595.

550. Seminar in Health and Physical Education (1-6) An in-depth analysis of current problems confronting the profession.

560. Administrative Problems of Physical Education in Schools (3) Solutions to problems emerging from the administration of physical education in schools, fitting physical education in the school's schedule, awards and budgets. Prerequisite: Ph.Ed. 491.

565. Neuromuscular Performance (3) Integrative action of the neural and muscular systems in effecting human movement with emphasis on motor performance. Prerequisites: Ph.Ed. 480, 490.

575. Motor Performance of the Handicapped (3) Motor performance of physically handicapped and mentally retarded. Activities and therapeutic exercises for the formulation of individualized programs. Prerequisites: Ed.Ser. 409, E.E.C. 410.

576. Internship in Adapted Physical Education (3) Supervised internship in recreational, educational, or clinical situations; assessment of motor performances, evaluation of activities, and staff conference participation.

581. Biomechanics (3) Kinetic and kinematic analyses of human motion utilizing electromyography and stroboscopic-photographic techniques. Prerequisite: Ph.Ed. 480.

582. Advanced Kinesiology (3) Analysis of sports movements utilizing cinematography, electronic devices, and related research instruments.

583. Special Topics in Biomechanics (1-6) Critical review of current research in biomechanics, culminating in individual research projects. Prerequisite: Ph.Ed. 581 or 582.

585. (Phsio. 585) Applied Physiology (3) Presentation of current thinking on physiological mechanisms with emphasis on physically active man. Prerequisite: 3 credits in physiology at the 400 or 500 level.

586. (Phsio. 586) Research Methods in Applied Physiology (3) Historical and current procedures for evaluation of cardio-pulmonary function, metabolism, and thermal balance in man; lecture, demonstration, and student laboratory. Prerequisite: 3 credits in physiology at the 400 or 500 level.

588. (Phsio. 588) Special Topics in Applied Physiology (1-6) Critical discussion and evaluation of current research in applied physiology. Prerequisite: Ph.Ed. 585.

589. (Phsio. 589) Physiology of Pulmonary Respiration (2) Physiology of the lung including physical and chemical properties, synthesis of cellular constituents, gas exchange, and effects of unusual environments. Prerequisite: 3 credits of physiology at 400 or 500 level.

595. Philosophy of Sport and Physical Education (3) Prerequisite: Ph.Ed. 491 or Rc.Pk. 465.

PHYSICAL SCIENCE (PH SC)

THOMAS A. WIGGENS
Chairman of the Committee on Physical Science
S-6 Osmond Laboratory

Degrees Conferred: D.Ed., M.Ed.

The M.Ed. program, designed to meet the needs of secondary school science teachers, requires at least 24 credits chosen from chemistry, physics, astronomy, mathematics, earth sciences, and biological sciences, including at least 9 each in chemistry and physics. In addition, a minor of at least 6 credits in education is required. The student must also complete a satisfactory term paper on a subject approved by the committee.

For admission to either the M.Ed. program or the D.Ed. program, the student is expected to have completed two years of college chemistry, one year of college physics at a level requiring calculus, mathematics through differential equations, and 18 credits in appropriate education and psychology courses.

For the D.Ed. degree, the student is required to complete 24 credits in physical science, including chemistry, earth sciences, mathematics, and physics, which *may* be (but are not required to be) in courses designed specifically for teachers. He is expected, beyond this, to complete 36 credits in standard 400- and 500-level courses, which *may not* be courses designed primarily for teachers; of these, 12 credits must be in chemistry, 12 in physics, and 12 in science and mathematics courses approved by the student's doctoral committee. In addition, 15 credits in education courses and 15 credits of thesis research are required. The student's selection of science courses should include at least 6 credits in experimental physics or chemistry.

A limited amount of work can be done during summer terms or off campus, but a candidate must plan to be on the University Park Campus for at least four consecutive terms after he has been accepted as a D.Ed. candidate. The student will be required to take a candidacy examination after having completed about 30 credits of graduate study, and a comprehensive examination after having completed his required course work. He must also present and defend a thesis, which may be either an experimental study in physics or chemistry, or an investigation of a problem in the teaching of physical science.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

See also Earth Sciences, Mathematics, and Physics.

PHYSICS (PHYS)

ROLAND H. GOOD, JR., *Head of the Department*
104 Davey Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Atwater, Barsch, Bleuler, Cutler, Eastman, Feuchtwang, Fleming, Frankl, Freed, Henisch, Herman, Kazes, Kendall, Madjid, McCammon, McCubbin, McKelvey, Müller, Pliva, Polo, Pratt, Skudrzyk, Strother, Thwaites, Vedam, Weber, Whitfield, and Wiggins.

Graduate Faculty: Associate Members Graetzer, Grotch, Lochstet, Nishikawa, Reed, Rendulic, Shaw, and Tsong.

PHYSICS

Graduate instruction and research opportunities are available in visible and infrared spectroscopy, laser physics, solid state, field emission, thermionic emission, photoelectric emission, acoustics, low-temperature physics, nuclear physics, physics of high polymers, and of carotenoids, electron spin resonance of solids, and various phases of theoretical physics.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by reading or introductory knowledge of one foreign language chosen from French, German, or Russian.

A bachelor's degree in physics or an allied field is required for admission to the M.S. and Ph.D. programs. Students who lack some of the usual upper-class undergraduate courses in physics may be requested to take additional course work without degree credit.

For admission to the M.Ed. program a student is required to have completed one year of general college physics plus two acceptable intermediate courses in physics, mathematics through integral calculus, and 18 credits in education and related psychology. The program requires at least 18 credits in physics, including approved laboratory work such as Phys. 560; at least 3 credits each in chemistry and mathematics; and at least 6 credits in education. With the approval of the head of the department the nonthesis option is available for the M.S. degree.

Students with a 2.50 junior-senior average in physics and mathematics will be considered for admission to the M.S., D.Ed., and Ph.D. programs. He will be considered with a 2.50 junior-senior average in all courses for admission to the M.Ed. program. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. Exceptions may also be made, at the discretion of the department, for applicants for doctoral programs who have satisfactorily completed master's degrees at other institutions.

PHYSICS (PHYS)

400. Intermediate Electricity and Magnetism (4)
402. Electronics (4)
406. Nuclear Physics (3)
410. Introduction to Quantum Mechanics (3)
412. Solid State Physics I (3)
413. Solid State Physics II (3)
419. (A.M. 419) Theoretical Mechanics (3)
420. Classical Thermodynamics (2)
421. Thermal Physics (2)
433. Mechanics and Fluid Physics for Teachers (3)
435. Electricity and Magnetism for Teachers (3)
439. Elementary Survey of Modern Physics for Teachers (3)
443. Intermediate Acoustics (3)
454. Atomic and Nuclear Physics (3)
456. Atomic and Molecular Physics (3)
457. Experimental Physics (1-2 per term)
458. Intermediate Optics (4)
461. (A.M. 461) Theoretical Mechanics (3)
467. Intermediate Electricity and Magnetism (3)
470. Special Topics (1-9)
471. Quantum Theory of Atoms and Molecules (3)

512-513. Introduction to the Quantum Theory of Solids (3 each) Energy band theory; electrical, optical, and magnetic properties; lattice dynamics; transport theory. Prerequisites: Phys. 412, 517.

517. Statistical Mechanics (3) Classical and quantum statistics; statistical thermodynamics; the Boltzmann transport equation; methods illustrated with applications to physical problems. Prerequisites: Phys. 420, 561.

518. Advanced Topics in Thermodynamics and Statistical Mechanics (3) Selected topics related to nonequilibrium thermodynamics, many-body problem, fluctuations, and statistical theory of random processes. Prerequisite: Phys. 517.

524. Physics of Semiconductors (3) Band structures, theory of electron and hole conduction, transport properties, excess carrier distributions, p-n junctions, metal-semiconductor contacts, semiconductor surfaces. Prerequisite: Phys. 412.

525. Methods of Theoretical Physics (3) Vector and tensor analysis; generalized coordinate systems; matrices and linear vector spaces of finite and infinite dimensionality; calculus of variations. Prerequisite: advanced calculus.

526. Methods of Theoretical Physics (3) Continuation of Phys. 525: complex variables; Hilbert space; Green's functions; orthogonal functions and boundary value problems. Prerequisite: Phys. 525.

530. Theoretical Mechanics (3) Newtonian mechanics; Lagrange's equations, Hamilton's principle; Hamilton's equations; coupled systems; waves in strings, central field problem; rigid bodies; elasticity; hydrodynamics.

532. Advanced Theoretical Mechanics (3) Least action principle, canonical transformations, Lagrange and Poisson brackets, Hamilton-Jacobi equations, classical theory of fields. Prerequisite: Phys. 530.

533. Theoretical Acoustics (3) Vibrating systems; transmission of disturbances through elastic and viscoelastic media. Prerequisite: Phys. 530.

550. (A.M. 550) Applied Group Theory (3) Representations of discrete and continuous groups, applications to theoretical physics and differential equations, varying emphasis on the specific applications. Prerequisite: A.M. 510.

553-554. Nuclear Physics (3 each) Discussion and theoretical interpretation of basic experiments involving atomic nuclei and nuclear radiations. Prerequisite: Phys. 562.

557. Electricity and Magnetism (3) Electro- and magnetostatics, Maxwell's equations, boundary value problems, electric and magnetic properties of material media.

558. Advanced Electricity and Magnetism (3) Energy and momentum in the field, radiation theory, classical relativistic electron theory. Prerequisite: Phys. 557.

561-562. Quantum Mechanics (3 each) The basic theory of wave and matrix mechanics, approximation methods, applications. Prerequisite: Phys. 530.

563-564. Advanced Quantum Mechanics (3 each) Relativistic wave equations, quantum field theory, other advanced quantum theoretical topics. Prerequisite: Phys. 562.

571. Atomic Physics (3) Experimental basis of modern physics; atomic spectra and structure, nuclear phenomena.

PHYSIOLOGY (PHSIO)

ADAM ANTHONY
Chairman of the Committee on Physiology
418 Life Sciences Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Almquist, Amann, Anthony, Baumgardt, Bortree, Buskirk, Buss, Cornwell, Dunson, Gaffney, Hale, Hymer, Jeffries, Leach, McCarl, Mendez, Morgan, Mortimore, Mueller, B. Pubols, H. Schraer, R. Schraer, Smyth, Strother, and Wickersham.

Graduate Faculty: Associate Members Eberhart, Hollis, Jefferson, Kollias, Martin, Mitchell, Neely, Neff, Nicholas, L. Pubols, Rhoades, Scholz, and Zarkower.

This is an intercollege program designed to enable students to obtain an integrated series of courses encompassing both the fundamentals of physiology and advanced training in a specialized area.

Graduate instruction in physiology is under the direction of a program committee composed of graduate faculty representing several departments or groups actively participating in the physiology program, including the areas of animal science, biochemistry, biophysics, and zoology, and the Human Performance Research Laboratory. The instructional staff is composed of the program committee as well as faculty in those departments offering graduate courses in various areas of specialization in physiology. The program, including courses, laboratory experience, and original research, is designed for completion in three to four academic years. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests.

The entering student who lacks adequate preparation in chemistry, mathematics (through calculus), physics, or biological science must make up the deficiency early in his graduate program. All candidates (master's and doctoral) must complete a general basic laboratory course in physiology (combined cellular, mammalian, and comparative) before choosing an area of specialization. Possible areas of specialization are cellular and subcellular physiology, environmental physiology, endocrinology, reproductive physiology, applied physiology (human performance), physiology of nutrition and metabolism, neurophysiology, or comparative physiology. The graduate committee for majors shall be appropriately represented by members of the physiology program committee and those of the area of specialization who shall have the responsibility and jurisdiction for determining the course program and research acceptable in satisfying degree requirements. The nonthesis option is available for the M.S. degree.

The following courses are available for physiology majors, and their descriptions may be found under the offerings of several departments: Anthy. 401; A.I. 514; A.Ntr. 401, 402, 505; Bioch. 401, 402, 417, 437, 438, 501, 519, 521; Biol. 462, 470, 472, 473, 475, 479, 538, 539, 541, 583; Bphys. 473, 474, 475, 580, 588; D.Sc. 427, 431, 512, 515, 521; Micrb. 401, 508; Nutr. 452, 457, 459, 552, 557; Ph.Ed. 480; Psy. 402, 403, 503; V.Sc. 535.

The following courses in physiology and biochemistry are offered at The Milton S. Hershey Medical Center: Anat. 505, 510, 535; Bchem. 502, 503, 513, 523, 540, 570, 590; Phsio. 520, 521, 525, 530, 550, 570, 590. Descriptions of these courses may be found under the designated program.

PHYSIOLOGY (PHSIO)

501. Seminar (1 per term)

532. Reproductive Physiology (3) Physiology of male and female reproductive systems, including synthesis, regulation of secretion and mechanism of action of the steroids and polypeptide hormones involved. Prerequisites: Phsio. 520, 521.

534. Heart and Skeletal Muscle (2) Discussion of structure, chemistry, and physiology of heart and skeletal muscle. Prerequisites: Phsio. 520, 521.

536. Gastrointestinal Physiology (2) Mechanisms of absorption and secretion by stomach, intestine, pancreas, and gallbladder. Neural and hormonal regulation, bioelectric potentials, pathophysiology. Prerequisite: Phsio. 521.

571. (Biol. 571) Animal Physiology (2) Physiology and fluid transport mechanisms; examination of the distribution and regulation of body fluids, blood and hemodynamics. Prerequisite: 3 credits in physiology.

572. (Biol. 572) Animal Physiology (2) Examination of nutrition, metabolism, and respiration as they relate to subcellular, cellular, and organ organizational levels of the whole animal. Prerequisite: 3 credits in physiology.

573. (Biol. 573) Animal Physiology (2) Detailed examination of animal reproduction, endocrine secretion and control, neural muscular activity, central nervous system correlates, and special senses. Prerequisite: 3 credits in physiology.

574. (Biol. 574) Animal Physiology Laboratory (1-6) Selected problems using advanced physiological techniques to study transport mechanisms, circulation, excretion, respiration, metabolism, and neuroendocrines. Prerequisite: Biol. 473.

585. (Ph.Ed. 585) Applied Physiology (3) Presentation of current thinking on physiological mechanisms with emphasis on physically active man. Prerequisite: 3 credits in physiology at the 400 or 500 level.

586. (Ph.Ed. 586) Research Methods in Applied Physiology (3) Historical and current procedures for evaluation of cardio-pulmonary function, metabolism, and thermal balance in man; lecture, demonstration, and student laboratory. Prerequisite: 3 credits in physiology at the 400 or 500 level.

588. (Ph.Ed. 588) Special Topics in Applied Physiology (1-6) Critical discussion and evaluation of current research in applied physiology. Prerequisite: Phsio. 585.

589. (Ph.Ed. 589) Physiology of Pulmonary Respiration (2) Physiology of the lung including physical and chemical properties, synthesis of cellular constituents, gas exchange, and effects of unusual environments. Prerequisite: 3 credits of physiology at 400 or 500 level.

PLANT PATHOLOGY (PPATH)

James Tammen, *Head of the Department*
211 Buckhout Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Bloom, Boyle, Cole, Kneebone, Lewis, Lukezic, Merrill, Mills, P. Nelson, R. Nelson, Schisler, and Tammen.

Graduate Faculty: Associate Members Hyre, Lacasse, Leath, Stouffer, and Wuest.

PLANT PATHOLOGY

Plant pathology is the study of disease in plants and concerns the dynamic interaction between the plant, the causal agent (bacteria, fungi, viruses, nematodes, etc.), and their environments. A student prepares for a professional career in research, teaching, extension, or industry through advanced studies of the principles of plant infection, the physiology of disease in plants, the ecology of root diseases, the nature and inheritance of disease resistance in plants, epidemiology, ecology and physiology of air pollution injury to plants, or plant disease control by biological or chemical means. A student also may specialize in the nature and control of the diseases of forest trees, agronomic or horticultural crops, and commercial mushrooms. Advanced studies in applied mycology, related to the production of the commercial mushroom, also may be taken. Modern, well-equipped laboratories, controlled environment facilities and greenhouses, and well-developed field research areas are available for graduate study.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

For admission a student must present 42 credits in the natural sciences, including a minimum of 15 credits in the plant sciences and a minimum of 15 credits in mathematics, chemistry, or physics. Students with a strong background in agronomy, biochemistry, biophysics, botany, forestry, genetics, horticulture, or microbiology are usually well prepared for advanced study in plant pathology.

Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests.

PLANT PATHOLOGY (PPATH)

401.	Theory and Concepts of Plant Pathology (3)	*Mr. Merrill*
402.	Diseases of Economic Plants (2)	*Mr. Merrill*
408.	Plant Pathological Techniques (3)	*Mr. Bloom*
420.	Plant Pathogenic Bacteria (3)	*Mr. Lukezic*
422.	Introduction to Plant Virology (3)	*Mr. Boyle*
424.	Environmental Pathology (3)	*Mr. Lacasse*
429.	Phytonematology (3)	*Mr. Bloom*
430.	History of Plant Pathology (2)	*Mr. Merrill*

501. Clinical Plant Pathology (1-3) Diagnosis and prognosis of disease; observe and evaluate the implementation of control practices. Prerequisite: P.Path. 408. *Mr. Wuest*

540. Plant Disease Control (3) Principles of plant disease control, including theoretical considerations involved in control by chemical and nonchemical means. *Mr. Cole*

541. Physiology of Plant Disease (3) Physiology of the diseased plant, including the host response to the pathogen and parasitic properties of the pathogen. Prerequisite: Biol. 443. *Mr. Lukezic*

542. Epidemiology of Plant Diseases (4) Disease development in populations of plants, with emphasis on the impact of environment and control practices on rate of development. Prerequisite: 9 credits in plant pathology.

543. Pathogen Variation and Host Resistance (3) Mechanisms and implications of genetic variation in plant pathogens related to breeding for disease resistance in plants by genetic means. *Mr. R. R. Nelson*

544. Pathological Plant Anatomy (2) Structural manifestations occurring in diseased plants. Prerequisites: Biol. 407, P.Path. 408. *Mr. P. E. Nelson*

560. Principles of Plant Pathology (3) Open-ended discussions of concepts of plant pathology, with emphasis on their interrelationships and their significance to the science. *Mr. R. R. Nelson*

POLITICAL SCIENCE (PL SC)

Robert S. Friedman, *Head of the Department*
107 Social Sciences Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Albinski, Aspaturian, Atwater, Brown, Friedman, Kochanek, Mowitz, Petras, and Silva.

Graduate Faculty: Associate Members Chang, Keynes, LaPorte, and Lee.

M.A. candidates will be comprehensively examined in American politics, comparative politics, international relations, political philosophy, or public administration. Candidates offering the thesis plan will also offer course work in one other of these substantive fields, or from among selected empirical theory-methodology courses. Candidates offering the nonthesis plan will offer course work in two of the above six fields. Ph.D. candidates will be comprehensively examined in four of the above fields, or in three departmental fields, and in a minor field or fields. Course work in empirical theory and scope and methodology is required. The communication and foreign language requirement for the Ph.D. may be satisfied by competence in approved skills selected from among foreign languages, statistics or mathematics, and computer science.

Students with a 3.00 junior-senior average and appropriate course backgrounds, including at least the equivalent of 12 credits in political science, will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. At the master's level two letters of recommendation and scores on the Graduate Record Examination (disciplinary, verbal, and quantitative ability) are required. Admission to the Ph.D. program will entail evaluation of two letters of recommendation, scores on the Graduate Record Examination (disciplinary, verbal, and quantitative ability), and previous scholastic performance.

POLITICAL SCIENCE (PL SC)

401. Political Behavior (3) *Mr. King*
403. The Legislative Process (3) *Mr. Keynes*
411. American Political Theory (3) *Messrs. Spence and Wikse*
412. International Organization: Economic and Social Functions (3) *Mr. Atwater*
413. Government and Politics of the Soviet Union (3) *Messrs. Aspaturian, Atwater, and Gilberg*
414. Foreign Policy of the Soviet Union (3) *Mr. Aspaturian*
415. International Organization: Political and Security Functions (3-6) *Miss Loomis; Messrs. Aspaturian, Atwater, and Brown*
416. International Law (3) *Miss Loomis*
417. American Local Government and Administration (3) *Messrs. Cook, Johnson, and Lee*

418. International Relations Theory (3) *Miss Loomis*
419. Bureaucracy and Public Policy (3) *Messrs. Friedman, Johnson, and Lee*
425. Government and Politics of the American States (3) *Messrs. Friedman and O'Connor*
426. Political Parties (3) *Miss Silva and Mr. King*
427. Political Opinion (3) *Miss Silva and Mr. O'Connor*
431. Ancient and Medieval Political Theories (3) *Messrs. Spence and Wikse*
433. (L.M.R. 433) The Law of Labor-Management Relations (3)
441. Anglo-American Legal Systems (3) *Mr. Keynes*
442. American Foreign Policy (3) *Messrs. Atwater and Brown*
443. Current Problems in American Foreign Policy (3) *Messrs. Atwater and Brown*
444. Government and the Economy (3) *Mr. Wissel*
445. Administrative Law (3)
447. Constitutional Law: The Federal System (3) *Miss Silva*
448. Constitutional Law: First Amendment Freedoms (3)
450. Canadian and Australian Politics and Foreign Policies (3) *Mr. Albinski*
451. Comparative Political Analysis (3) *Mr. Albinski*
452. Governments and Politics of Eastern Europe (3) *Mr. Gilberg*
453. Political Processes in Underdeveloped Systems (3) *Messrs. Chang, Kochanek, LaPorte, and Petras*
454. Government and Politics of Africa (3) *Messrs. Brown and Kingsland*
455. Governments and Politics of Western Europe (3) *Mr. Gilberg*
456. Politics and Institutions of Latin-American Nations (3) *Mr. Petras*
457. International Politics of Latin America (3-6) *Mr. Petras*
458. Government and Politics of East Asia (3-6) *Mr. Chang*
459. Government, Politics, and International Relations of South Asia (3) *Mr. Kochanek*
460. Liberal and Democratic Political Theory (3) *Messrs. Spence and Wikse*
461. Authoritarian and Elitist Political Theory (3) *Messrs. Spence and Wikse*
462. Marxist and Socialist Political Theory (3) *Messrs. Spence and Wikse*
468. International Relations of East Asia (3) *Mr. Chang*
469. International Relations in South Asia (3-6) *Mr. Kochanek*
473. Constitutional Law: Civil Rights (3) *Miss Silva*
499. Foreign Study in Government (2-6)

500. Political Power (3-6) Subject to be announced.

505. Executive Power (3-6) *Miss Silva*

509. Scope and Method of Political Science (3-6) *Mr. King*

512. Comparative Political Systems (3-9) *Messrs. Albinski, Kochanek, and Petras*

513. Seminar in Comparative Political Parties (3-6) Nature, function, organization, and leadership of parties; party systems, political culture, voting, and the institutional framework. *Mr. Albinski*

515. International Politics (3-6)

516. Seminar in International Relations Theory and Methodology (3) A detailed analysis of major traditional and contemporary theory-building efforts and contemporary research techniques and orientations in international relations.

517. International Organization (3-6) *Messrs. Aspaturian and Atwater*

521. Modern Democratic Political Theory (3-6)

522. Comparative Foreign Policies (3-6) Major policies of selected nations which bear upon the search for international peace and security. *Mr. Aspaturian*

523. Soviet Political Behavior (3) Forces which shape rivalries for power; decision-making processes; areas of agreement and dissent. *Mr. Aspaturian*

524. Foreign Policies of the Soviet Bloc (3-6) Major policies, the decision-making process, and the impact upon component members and external rivals for power. *Mr. Aspaturian*

525. Comparative American State and Local Politics (3-6) Literature and research in comparative state and local political systems in the United States. *Mr. Friedman*

527. Politics and Legislative Behavior (3-6) Social factors which shape and determine the attitudes and decisions of American legislators and legislative bodies. *Mr. Keynes*

528. (Ed.Adm. 528) Politics and Education (3) Social forces which shape the educational system and determine national, state, and local educational policies.

529. Federal Systems (3-6) Features of the American federal system compared with those of other nations using the federal form.

530. Public Law (3-6) The nature of law and its role in modern society. *Miss Silva*

531. Marxism and Political Socialist Theories (3) A systematic analysis and appraisal of major premises and deductions. *Mr. Aspaturian*

532. Empirical Political Theory (3-6) The impact of scientific method upon traditional political thought. *Mr. Keynes*

546. Judicial Process (3) Court functions in the political process; sources and limits of judicial power; perceptions of the judicial role; judicial decision making. Prerequisite: 12 credits in political science. *Miss Silva and Mr. Keynes*

554. African Political Systems (3-6) Impact of European colonialism; cultural and anthropological factors in political development; modernization and analysis of selected problems in contemporary Africa. Prerequisite: 3 credits of comparative government or international relations at the 400 level. *Mr. Brown*

571. Theory of Public Administration (3-6) The role of the executive in modern government; the objectives of public administration; theories of administrative organization and practice. *Mr. Mowitz*

572. International Development Administration (3-6) The execution of foreign policies through national and international public and private organizations. *Mr. LaPorte*

573. Comparative Public Administration (3-6) Administrative systems of selected nations on a functional basis; relationship between culture, economic and social systems, and public administration. *Mr. LaPorte*

574. Seminar in the Administration of United States Foreign Affairs (3) Effect of cross-cultural operations on the normal process of administration of United States foreign affairs. *Messrs. Brown and LaPorte*

575. Government Manpower Management (3) Government personnel systems; current trends and problems; essentials of recruitment, classification and pay, ratings, supervision, training, and discipline.

576. Government Fiscal Decision Making (3) The role of the executive in fiscal planning; budget preparation; expenditure control; tax assessment and collection; investment of public funds.

577. Organization and Systems Management (3) Principles of government organization; management surveys; work measurement; methods of achieving efficiency and economy. *Mr. Mowitz*

578. Urban Administrative Systems (3) Urban areas as administrative and policy systems; urban responses to problems of policy planning and implementation; approaches to urban analysis.

579. Methods of Analysis and Measurement in Public Administration (3) Examination and application of analytical techniques for evaluating organizational performance and program effectiveness in government agencies. *Mr. Cook*

580. Internship in Public Administration (6)

584. Research Seminar in Public Administration (1-6) Application of research methods to problems of organization, management, and policy in public agencies; preparation of research project and report.

594. Readings in Political Science (1-6) Directed readings in selected areas of the discipline.

595. Research in Political Science (1-6) Directed research in selected areas of the discipline.

POULTRY SCIENCE (PTYSC)

Kenneth Goodwin, *Head of the Department*
214 Animal Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Bressler, Buss, Goodwin, Hale, Leach, MacNeil, and Mueller.

Graduate Faculty: Associate Member Graves.

The department offers two types of graduate programs: (1) a program in poultry science, with one of the following major fields of interest: genetics, physiology, nutrition, behavior, food science, or poultry management; and (2) an interdepartmental program in one of the following disciplines: genetics, physiology, food science, or animal nutrition.

In either case, the student's major program and his thesis research will be under the direction of a faculty member in the Department of Poultry Science. The communication and foreign language requirement for the Ph.D. degree may be satisfied by reading ability in one foreign language.

Admission requirements include 30 credits in biology, chemistry, mathematics, and physics. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

POULTRY SCIENCE (PTYSC)

402. Special Topics (3-12) *Staff*
405. Poultry Production Technology (3) *Mr. Keene*
462. (Biol. 462) Animal Behavior—Ethology (3)
463. (Biol. 463, Psy. 463) Animal Behavior Laboratory (1-2)

502. Advanced Poultry Nutrition (2-4) *Mr. Leach*

503. Advanced Poultry Farm Management (2-4) *Mr. Bressler*

504. Poultry Meat and Egg Technology (2-6) Prerequisites: Fd.Sc. 212 and 2 additional credits in poultry science. *Mr. MacNeil*

582. (Biol. 582, Psy. 582) Research in Animal Behavior (2-6 per term) Research in special areas of animal behavior involving field or laboratory work. *Messrs. Graves and Hale*

Note: *See Animal Science under "Other Elective Graduate Courses." Also see Food Science.*

PSYCHOLOGY (PSY)

Merrill E. Noble, *Head of the Department*
417 Psychology Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Berman, Cofer, Cornwell, Draguns, Gorlow, Greenhill, Guthrie, Hale, Hall, Harris, Leibowitz, Lundy, Mitzel, Noble, Palermo, Seibel, Sherif, Stern, Taylor, Thevaos, Thomas, Trumbo, Urban, and Warren.

Graduate Faculty: Associate Members Dubin, Kazdin, Landy, Martin, Piers, and Whaley.

Graduate instruction and research opportunities are available in the following areas of psychology: general experimental, physiological and comparative, perception, social and personality, developmental, child, clinical, organizational, engineering and human factors, verbal learning, and psycholinguistics.

The communication and foreign language requirement for the Ph.D. degree does not specify a foreign language but a student must demonstrate proficiency in English.

Special research and training facilities include the Penn State Anechoic Chamber, the University Computation Center, the Animal Behavior Laboratory, the Psychology Clinic, the Division of Counseling, and the Special Education unit.

Requirements for admission include a broad undergraduate preparation, a minimum of 12 credits in psychology, and a satisfactory graduate student rating on the Miller Analogies Test, and the Graduate Record Examination (General). Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Applicants with master's degrees will have their admission evaluated with emphasis on the quality of their graduate programs.

PSYCHOLOGY (PSY)

402. Sensation and Perception (3)
403. Introductory Physiological Psychology (3)

404. Conditioning and Learning (3)
405. The Experimental Psychology of Visual Perception (3)
406. Experimental Social Psychology (4)
408. Comparative Psychology (3)
409. Techniques in Laboratory Experimentation (2-6)
410. History of Psychology (3)
412. Abnormal Psychology (3)
413. Biographical Psychology (3)
415. Intermediate Experimental Design (3)
417. Social Psychology (3)
418. Measurement of Personality (3)
420. (Ling. 420) Advanced Psycholinguistics (3)
425. Child Psychology (3)
426. Adolescence (2-3)
430. Memory and Verbal Learning (3)
431. Industrial Psychology (3)
432. Introductory Engineering Psychology (3)
433. Psychology of Occupational Behavior (2)
434. Information-Processing Laboratory (1-6)
436. Mental Health in Schools (3)
437. Psychology of Adjustment (3)
438. Theory of Personality (3)
440. Psychology Projects (1-6)
441. Industrial Motivation and Morale (3)
445. (I.F.S. 445) Development Throughout Adulthood (3)
450. (Ed.Psy. 450) Principles of Measurement (3)
452. Laboratory in Sensory Processes (2-4)
453. Neuroanatomy Laboratory (1)
455. Physiological Psychology Laboratory (3)
456. Laboratory in Psychophysiology (2-4)
463. (Biol. 463, Pty.Sc. 463) Animal Behavior Laboratory (1-2)
474. Psychology of Exceptional Children (3)
482. Introduction to Clinical Psychology (3)

500. Seminar: Introduction to Graduate Study (2-6) Required of all new graduate majors in psychology.

503. Physiological Psychology (2-6) Correlations between structure and function of nervous system and human consciousness; laws and theories in fields of sensation, attention, association, affection, and thought. Prerequisite: 9 credits in psychology.

505. Research Problems in Psychology (1-15) Prerequisite: 12 credits in psychology.

509. Seminar in Conditioning and Learning (3-9) Prerequisite: Psy. 404 or Ed.Psy. 421.

511. Seminar in Contemporary American Psychology (1-9) Critical review of readings on a topic of current interest, either in content or methodology, within psychology. Prerequisite: 9 credits in psychology.

515. Advanced Statistics in Psychology and Education (3) Correlation theory and methods, discriminant function, and factor analysis; applications to mental test theory. Prerequisite: Psy. 415 or Ed.Psy. 506.

516. Seminar in Quantitative Models (3-9)

518. Projects in Experimental Psychology (2-4) Individual experimental projects; seminars on experimental design and instrumentation.

520. (Ling. 520) Seminar in Psycholinguistics (3) The relationship between the behavioral, probabilistic view and the structuralist, deterministic view of language as a system of habits.

527. Statistical Inference and Experimental Design (3) Probability theory, sampling distributions, analysis of variance and covariance, analysis of trend, nonparametric statistics, experimental design. Prerequisite: Psy. 415 or Ed.Psy. 506.

529. (I.F.S. 529) Seminar in Child Development (1-6) Readings and reports on recent findings in child development. Prerequisites: 6 graduate credits in child development, child psychology, or educational psychology, plus 3 in statistics.

531. Seminar in Performance Theory (3-9) Topics in theory and research on human performance in perceptual-motor and information-processing tasks. Prerequisite: Psy. 432.

533. Seminar in Engineering Psychology (2-9) Design and operation of machines, man-machine allocation, the man-machine interface, displays, system-design, decision making, image evaluation, and motor behavior. Prerequisite: Psy. 432.

535. Developmental Psychology (2-3) Developmental principles and concepts applied to psychological processes, with special reference to the experimental literature. Prerequisite: 9 credits in psychology.

536. (I.F.S. 536) Research Methods in Developmental Processes (3) Methodological issues in research on varying stages of development across the individual life-span. Prerequisites: 6 credits in individual development or psychology and a course in statistics.

537. Seminar in Industrial Psychology (1-9) Prerequisite: Psy. 431.

538. Psychology of Personnel Development (3) Industrial training in relation to psychological learning theory and experimental findings. Prerequisite: Psy. 431 or Ed.Psy. 421.

539. Seminar in Motivation and Emotion (3-9) Systematic status of instinct, drive, motive, will, purpose; methodology and results of physiological, experimental, and clinical investigation of basic drives.

540. Seminar in Clinical Problems (1-9) Contemporary psychological theory, research, and methodology in relation to clinical psychology. Prerequisites: Psy. 542, 560.

541. Personality Theory (3-4) Contemporary theories of personality; relevant research. Prerequisite: Psy. 438.

542. Psychopathology (3-4) Theories of pathological behavior with reference to clinical and experimental data. Prerequisite: Psy. 412.

545. Seminar in Verbal Learning and Verbal Behavior (1-9)

549. (I.F.S. 549) Developmental Theory (3) Conceptual frameworks and major contributions to the study of individual development across the life-span. Prerequisite: 6 credits at the 400 level in individual development or psychology.

555. Theory and Practicum in Clinical Assessment (3-9) Theoretical issues and research in clinical assessment with special reference to administration and interpretation of testing procedures and clinical interviewing. Prerequisites: Psy. 541 or 542, and a course in measurement.

558. Clinical Child Psychology (3-9) Psychopathology of childhood; theories of etiology; diagnosis and treatment. Prerequisites: Psy. 555, 561.

559. (S.Psy. 559) The Individual Psychological Examination (3) Demonstrations and practice in widely used ability and aptitude tests; psychological report writing. Prerequisites: 15 credits in psychology and a course in measurement.

560. Practicum in Clinical Methods (1-6) Supervised practice in the Psychology Clinic, including assessment, therapy, report writing, and staff participation. Prerequisite: Psy. 555.

561. Clinical Practicum with Children (1-6) Diagnosis and counseling of child-parent problems of learning and adjustment. Prerequisites: Psy. 425, 426, 555.

569. Advanced Theory and Practicum in Counseling and Psychotherapy (3-9) Theoretical issues, research, and practicum experience in psychotherapy.

571. Seminar in Social Psychology (3-9) Historical development of theory and methods; determinants and principles of complex social or interactional behavior; contemporary problems and research.

580. Theory and Construction of Attitude Scales (3) Measurement of social, political, commercial, and industrial attitudes; questionnaire designs. Prerequisite: 3 credits in statistics.

581. Experimental Study of Primate Behavior (3) Taxonomy of contemporary species of primates; ontogeny of learning, perception, and affective behavior; interspecies comparisons of behavior.

582. (Biol. 582, Pty.Sc. 582) Research in Animal Behavior (2-6 per term) Research in special areas of animal behavior involving field or laboratory work.

589. Problems in Clinical Research (1-6) Prerequisite: Psy. 415.

591. Seminar on Teaching Psychology (1-3) Objectives and content of psychology; organization and presentation of material; teaching aids and techniques.

PUBLIC ADMINISTRATION (PUB A)

Robert J. Mowitz
Director of the Institute of Public Administration
208 Social Sciences Building

Degree Conferred: M.P.A.

Graduate Faculty: Senior Members Mowitz, Petras, and Riew.
Graduate Faculty: Associate Members LaPorte, Lee, and Westby.

All candidates take a core program consisting of six seminars which cover the theoretical, methodological, and technological components of public management science. An additional 12 hours may be elected, permitting the student to focus upon such areas as general public administration, systems analysis, management information systems, urban systems administration, natural resources administration, human resources administration, or any other related substantive area.

Candidates for admission ordinarily will have at least 12 hours of undergraduate credit in the social sciences. Candidates for the degree may be required to take some

courses without graduate credit in order to complete a major designed for their professional needs.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

PUBLIC ADMINISTRATION (PUB A)

Daniel M. Poore
Chairman, Public Administration Program at Capitol Campus
Middletown, Pa. 17057

Degree Conferred: M.P.A.

Graduate Faculty: Associate Members Brown, Murty, Poore, Saylor, and Woodruff.

This program is intended for individuals who are seeking or are currently engaged in professional careers as administrators, project directors, or staff analysts in urban and municipal government, state government, health and welfare organizations, and other public service agencies. In order to complete a program designed for their professional needs, students may be required to complete preparatory work in basic mathematics, statistics, micro- and macroeconomics, accounting, and introduction to computer programming. In addition, students must have sufficient preparation in political science and other social sciences, or equivalent experience, in order to perform satisfactorily in the program.

At the graduate level all students take 15 credits of common core courses from the areas of administrative theory, organizational behavior, the political process, and research methods. The core also requires a professional paper. In addition, 15 credits of electives are required in areas such as program planning and evaluation, personnel management, labor relations, fiscal management, urban problems, regional planning, current economic issues, quantitative decision-models, and other related areas.

Students with a 2.50 junior-senior average will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. Applicants are advised to present their scores on the Graduate Record Examination (verbal and quantitative ability) as part of their application materials.

Courses applicable to this program are listed under the program in administration at the Capitol Campus.

RECREATION AND PARKS (RC PK)

Betty van der Smissen
Associate Dean for Graduate Study and Research
275 Recreation Building

Degrees Conferred: M.S., M.Ed.

Graduate Faculty: Senior Members Gross, Nelson, and van der Smissen.
Graduate Faculty: Associate Members Harris and Lundegren.

The graduate program is designed to prepare students for administrative, supervisory, research, and teaching positions in public recreation and park systems, in colleges and universities, in voluntary agencies, and in institutions.

The program is oriented to meet the specific needs and research interests of the candidate. Areas of specialization include (1) recreation and park administration, including park planning, (2) recreation program supervision and administration, including recreation for special groups, (3) camping, outdoor education, and outdoor interpretive services, and (4) professional education.

The master's degree may be earned in the major program of recreation and parks. At the doctoral level, the Ph.D. and D.Ed. may be earned with a specialization in recreation and parks within the physical education major. Write for details.

For admission to the graduate program, a bachelor's or master's degree is required in recreation, park administration, or in a related field, e.g., forestry, landscape architecture, sociology, psychology, physical education, education, or fine arts. Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests.

RECREATION AND PARKS (RC PK)

420. Outdoor Recreation (3)
425. Interpretive Services (3)
430. Outdoor Education (3)
440. Camp Administration (3)
456. Recreation Program Organization (3)
458. Dynamics of Recreation Groups (3)
461. Community Recreation (3)
465. Administration of Recreation and Parks (3)
470. Metropolitan Park Management (3)
475. Therapeutic Recreation in the Community (3)
477. Therapeutic Recreation in the Rehabilitation Setting (3)
496. Special Projects (1-6)

500. (Ph.Ed. 500) Individual Study and Research Projects (1-10) Prerequisite: Rc.Pk. 530.

515. Program Development and Supervision (3) Critical analysis of the individual, political, and societal determinants of recreation programming; demonstration projects; evaluative procedures, research functions in programming. Prerequisite: Rc.Pk. 456.

520. Seminar in Camp Administration (3) Values inherent in the camp experience; critical analysis of philosophical choices and sponsor objectives as influencing program development. Prerequisite: Rc.Pk. 230 or 430.

530. (Ph.Ed. 530) Research Techniques in Health and Physical Education and Recreation (3)

533. Recreation Studies, Surveys, and Appraisals (3) Advanced research procedures related to special recreation and park problems. Prerequisites: Rc.Pk. 530 and 3 credits in statistics.

540. Public Recreation Lands (3) Planning recreation lands; legislation, financing, intergovernmental coordination to acquire and develop open space land, urban recreation and park master plan.

550. Seminar in Recreation and Parks (1-6)

560. Administrative Problems of Recreation and Parks (3) Special problems of recreation and park departments; legal powers and liability; departmental organization, financing, personnel policies, and staff development. Prerequisite: Rc.Pk. 465.

595. Philosophical and Social Bases of Recreation (3) Philosophical and social bases of recreation; analysis of critical issues of recreation for philosophical and social implications.

REGIONAL PLANNING (R PL)

Harry S. Coblentz
Chairman, Graduate Program in Regional Planning
211 Willard Building

James I. Clark
Program Head for Regional Planning
at the Capitol Campus

Degree Conferred: M.R.P.

The objective of this intercollege program is to train professional planners aware of the needs of citizens and the programs for sound social, political, economic, and cultural advancement through the enlightened management of all resources. Programs are offered at University Park and at the Capitol Campus in Middletown.

For admission a student should have had at least one course each in sociology, political science, economics, and statistics and at least one course each in any two of the following subjects: geography, cartography, and public administration. Applicants should submit scores on the Graduate Record Examination. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered up to the number of spaces available. Exceptions to the 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

REGIONAL PLANNING (R PL)

400. Principles of Regional Planning (3-6)
410. Planning Programs (3)
420. Theory and Methodology of Regional Planning (3)
440. Problems in Community and Regional Planning (1-9)

502. Regional Systems Analysis (3-6) Spatial structure of regional and interregional systems. Theories of regional development. Spatial measures of location, density, central tendency and dispersion.

510. Planning Techniques and Analysis I (3) Regional socioeconomic structure, problems, and factors in planning; data collection, analysis, and implications.

520. Planning Techniques and Analysis II (3) Interaction of man and environment; land and water resources in regional planning; environmental factors as planning parameters.

530. Planning Techniques and Analysis III (3) Physical, aesthetic, and cultural design aspects of planning. Cultural value judgments and environmental design.

540. Problems in Regional Planning (1-9) Planned individual projects involving library, laboratory (studio), or field work.

RELIGIOUS STUDIES (RL ST)

LUTHER H. HARSHBARGER, *Head of the Department*
N-431 Burrowes Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Cherry, Fukuyama, Harland, Harrison, and Harshbarger.

Graduate Faculty: Associate Members Vastyan and Whitney.

The emphasis of this program is on the comprehensive understanding of the various facets of religion in American culture, using a variety of methods of analysis and interpretation. A broad cross-disciplinary scope is encouraged in substantive areas with particular emphasis on the development of religious thought and movements and the relationships between religion and society. The student will assume the initiative and major responsibility for shaping his own program with a minimum of formal requirements under the supervision of faculty advisers. He can fulfill the degree requirements by working within the department as well as in cooperation with several other departments with offerings related to the general focus of the program.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by an intermediate knowledge of two foreign languages, by substitution of courses from other designated areas for one of these languages, or by a comprehensive knowledge of one foreign language.

Applications will be evaluated on the basis of the quality of undergraduate, graduate, or professional records, whichever is most appropriate, and on the basis of the candidate's clarity of understanding and interest in the specific emphases of the program as described above. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Graduate Record Examination scores, letters of recommendation, and a statement of the applicant's career goals and academic interests will be required.

RELIGIOUS STUDIES (RL ST)

402. SEMINAR IN CONTEMPORARY RELIGIOUS THOUGHT (3-6)
408. HINDUISM (3)
409. BUDDHISM (3)
421. CULTURE AND RELIGIOUS REFORM (3)
422. RELIGION AND AMERICAN CULTURE (3-6)
430. RELIGION AND MORALITY (3)
438. (Soc. 438) RELIGION AND URBAN SOCIETY (3)
440. PROBLEMS IN RELIGION (3-6)
461. (Soc. 461) SOCIOLOGY OF RELIGION (3)
470. (Sec.Ed. 470) WESTERN RELIGIOUS LITERATURE FOR SECONDARY SCHOOL TEACHERS (3)
471. (Sec.Ed. 471) EASTERN RELIGIOUS LITERATURE FOR SECONDARY SCHOOL TEACHERS (3)

502. STUDIES IN COMPARATIVE RELIGIONS (3-6) Cross-cultural comparative studies of two or more world religions.

505. SEMINAR IN ASIAN RELIGIONS (3-6) Studies in selected Asian religions.

520. Early and Medieval Western Religion (3-6) Studies in Judaism and Christianity from the first century A.D. to 1500.

523. Religion of the Puritans (3) Religious ideas, institutions and leaders of the Puritan movement in England and America; relation of Puritans to cultural developments.

530. Religion and Society (3-6) Studies of mutual influences and effects of religion and secular phenomena.

RURAL SOCIOLOGY (R SOC)

Lee M. Day
Head of the Department of Agricultural Economics and Rural Sociology
6A Weaver Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members Bealer, Brown, Smith, and Willits.
Graduate Faculty: Associate Member Warland.

In all degree programs emphasis is on a comprehensive understanding of the various facets of societal organization pertinent to the rural sector. While scope is encouraged, there are available certain areas of special interest and research: consumer behavior, instigated social change, community structure, human resource development, migration, adolescent behavior, the culture of poverty, the ecology of rurality in industrialized and urbanized society. All students are required to have training in sociological theory, statistics, and research methods.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by either (1) mastering one foreign language or (2) passing three graduate courses outside the major and minor fields having communications value.

The entering student in the master's program should have as prerequisites 3 credits in rural sociology, 3 credits in sociology, and 3 additional credits in either field. If he does not have these prerequisites, he may take them at the University during the early part of his master's program.

Students with a 2.75 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.75 grade-point average may be made for students with special backgrounds, abilities, and interests.

RURAL SOCIOLOGY (R SOC)

401. Special Topics in Rural Sociology (1-6)
402. Consumer Behavior and the Agricultural Industry (3) *Mr. Herrmann*
405. Leadership for Social Change (3) *Mr. Smith*
425. Poverty Analysis: People and Programs (3) *Messrs. Madden and Smith*
444. The Rural Transition in American Society (3) *Mr. Leadley*
452. Rural Organization (3) *Mr. Leadley*
459. Rural Social Psychology (3) *Mrs. Willits*

501. Development of Rural Sociology (2) Historical development with emphasis on American rural sociology.

502. Advanced Rural Sociology (3) Structure and functioning of rural society; evaluation of theoretical systems.

510. Rural Migration (2) Rural migration research and theory; application to governmental and community problems.

512. National Farm Organizations (2) National farm organizations as social systems. Prerequisite: R.Soc. 452.

513. Sociology of Consumer Behavior (2) Sociological theory and research pertaining to consumer behavior.

514. Values in Rural Society (2) Values as dynamic forces in rural society.

515. Extension Organization and Methods (2) Agricultural and home economics extension as a social system, with emphasis on techniques of organization and program development.

516. Change in Rural Society (2) Social change in rural society, emphasizing prediction and control of the change process.

551. Rural Sociology Seminar (1-6) Prerequisite: 6 credits in rural sociology, sociology, or psychology.

SANITARY ENGINEERING (S E)

Raymond E. Untrauer
Head of the Department of Civil Engineering
212 Sackett Building

Degrees Conferred: M.S., M.Eng.

Graduate Faculty: Senior Members McDonnell, Nesbitt, and Unz.

The entering student normally should be a graduate in engineering from an accredited college of engineering. A student wishing to obtain a Ph.D. degree may major in civil engineering with emphasis on sanitary engineering.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

The following courses offered by the Department of Civil Engineering are appropriate for students majoring in sanitary engineering (course descriptions are given under Civil Engineering): C.E. 451, 452, 462, 465, 471, 472, 476, 551, 553, 564, 571, 572, 573, 574, 575, 576, 577, 579, and 580. Appropriate courses offered by other departments include: Ag. 400; Ag.Ec. 422, 505; Bioch. 401, 402, 425; Biol. 410; Chem. 405; Cmp.Sc. 402; Geol. 452; I.E. 405, 509, 510; M.E. 405, 470, 506, 521, 571; Meteo. 473, 502; Micrb. 400, 417; Nuc.E. 420; Pl.Sc. 419, 578; P.Path. 424; R.Pl. 400, 410, 510, 520.

SCHOOL PSYCHOLOGY (S PSY)

Joseph L. French
Chairman of the Committee on School Psychology
102 Cedar Building

Degrees Conferred: D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members French, Gorlow, Noble, Rabinowitz, and Sabatino.
Graduate Faculty: Associate Members Snyder and Ysseldyke.

This intercollege program is based on courses in the Departments of School Psychology, Psychology, Educational Psychology, and Special Education (developmental and remedial reading, speech pathology and audiology, and education of exceptional children). Courses may also be drawn from Individual and Family Studies, Counselor Education, Sociology, Cultural Foundations of Education, Educational Administration, Elementary Education, and Secondary Education.

The objective is to develop a psychologist who is interested in and knowledgeable about education and psychology in the school setting. The school psychologist must utilize his professional skills and his knowledge about children and youth to make contributions which are meaningful to and utilized by teachers, other school personnel, and parents. The development of competences needed by a fully qualified school psychologist requires at least the education represented by a doctoral degree. Only those students who anticipate a doctoral degree will be admitted. Exceptions may be made for students with special backgrounds, abilities, and interests. Students are selected within the limitations of departmental facilities.

An undergraduate major emphasizing work in psychology and/or education is preferred, but students with fewer than 15 upper-division credits in psychology, educational psychology, or special education may be admitted with limited deficiencies to be fulfilled concurrently with their graduate work. Requirements for admission include a minimum junior-senior scholastic average of 2.85 or, for applicants with master's degrees, a minimum of one-third of graduate credits of "A" quality; satisfactory recommendations from two or more professors, preferably psychologists; and 500 or higher on the general sections of the Graduate Record Examination, 58 or higher on the Miller Analogies Test, and/or 35 or higher on the Quantitative Evaluative Device.

Practicum facilities include The Center for Educational Diagnosis and Remediation, the School Psychology Clinic, the Speech Pathology and Audiology Clinic, the Reading Center, the Psychology Clinic, the Campus Demonstration School for mentally retarded children, and those in nearby public schools. Facilities for work with children are also available through other departments, as well as through assistantship assignments.

Although additional courses from the supporting and other departments are utilized in doctoral programs, core courses from which school psychology students build a program for the school psychologist certificate issued by the Pennsylvania Department of Education are: C.F.Ed. 515; Cn.Ed. 403, 501, 503, 508, 592; D.R.R. 441, 444, 545; Ed.Adm. 480, 576; Ed.Psy. 400, 406, 407, 421, 450, 475, 506, 512, 513, 522, 523, 524; E.E.C. 400, 401, 403, 410, 420, 430, 454, 470, 480, 501, 554; Psy. 404, 412, 417, 418, 425, 426, 541, 542, 555, 558, 559, 561; S.P.A. 440.

SCHOOL PSYCHOLOGY (S PSY)

500. Professional Issues in School Psychology (1-3) Orientation to the field through study of unique problems, current issues, ethical and legal matters, unique cases, and research projects.

504. Practicum in School Psychology (1-6) Clinical experience with children under supervision in a variety of settings requiring service including practice in synthesizing data and observations.

508. Internship in School Psychology (1-10) Long-term placement in settings providing work for school psychologists with children, parents, teachers, administrators, and service agencies under supervision.

559. (Psy. 559) The Individual Psychological Examination (3) Demonstrations and practice in widely used ability and aptitude tests; psychological report writing. Prerequisites: 15 credits in psychology and a course in measurement.

SECONDARY EDUCATION (SECED)

Robert L. Lathrop
In Charge of Graduate Programs in Secondary Education
240 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Fagan, Fowler, Golub, Greenhill, Heimer, Miller, Searles, VanderMeer, and Withall.

Graduate Faculty: Associate Members Bell, Dupuis, Jerman, Johnson, Koble, Kozak, Ribble, Shemick, Szabo, and Welliver.

Graduate degree programs emphasize the advanced preparation of classroom teachers, special supervisory personnel, and curriculum specialists. Candidates for the D.Ed. and Ph.D. degrees with a major in secondary education must meet all the requirements, including residence, described in the earlier sections of this bulletin.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign languages.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. Also required is a provisional certificate to teach in secondary schools, two letters of recommendation, and scores on the Graduate Record Examination (aptitude and advanced sections). For admission to the D.Ed. program at least 18 credits in education and related psychology are required.

Candidates for the D.Ed. degree with a minor in secondary education must take a minimum of 15 course credits approved in advance by the person in charge of the major in Secondary Education. When course work has been completed more than five years prior to admission to the D.Ed. or when it is transferred from another institution, the chairman of the graduate faculty will determine its suitability for any part or all of the 15 hours required.

Candidates for the M.S. degree with a major in secondary education will fulfill all the requirements for that degree, including a thesis, which are listed previously in this bulletin. Candidates with a minor in secondary education must have 6 credits in education approved by the chairman of the graduate faculty. In general, candidates for the M.Ed. in secondary education must have 18 approved undergraduate credits in education and psychology including practice teaching in an area appropriate to the major, and aptitude for and interest in advanced professional preparation. Applicants are urged to have had at least two years of successful teaching experience before completion of the degree requirements. Although candidates are required to specialize in secondary education, they are encouraged to increase their general education in the social sciences, the behavioral sciences, and the humanistic foundations.

The M.Ed. degree may be earned in those fields outside of secondary education for which a master's degree has been approved, provided such a professional program is appropriate. For example, the M.Ed. degree may be earned with a major in English or geography. These programs require 6 credits in professional education approved

in advance by the head of the department or the person responsible for the minor field chosen, e.g., secondary education, agricultural education, etc.

Graduate Record Examination scores on both aptitude and education sections are required of all candidates.

SECONDARY EDUCATION (SECED)

400. Introduction to Research Literature (3)
426. Teaching Mathematics in the Secondary Schools (4)
431. Contemporary Secondary School Mathematics Programs (2)
433. Teaching Social Studies in the Secondary Schools (4)
436. Teaching of Conservation of Natural Resources in the Secondary School (3)
438. Teaching Science in the Secondary Schools (4)
441. Computers and the Teaching of Secondary School Mathematics (3)
451. Secondary Education in America (3)
453. Teaching English in the Secondary Schools (4)
470. (Rl.St. 470) Western Religious Literature for Secondary School Teachers (3)
471. (Rl.St. 471) Eastern Religious Literature for Secondary School Teachers (3)
472. Measurement of Achievement in the Secondary School (2-3)
490. (Human. 490) Humanities for Teachers (3)
497. Workshop in Selected Studies in Secondary Education (1-6)

510. Internship in Secondary School Teaching (3-6) Internship to take place in schools or educational situations where student is not regularly employed, under supervision of graduate faculty.

526. Research Problems in the Teaching of Mathematics (3) Research techniques and procedures dealing with the study of curriculum, materials, evaluation, teaching, learning, and supervision of mathematics. Prerequisites: Sec.Ed. 426, Ed.Psy. 406, and teaching experience.

530. Systematic Observation of Classroom Behavior (3) Construction and use of valid and reliable systematic observation systems used as a basis for classroom observation of instruction. Prerequisite: student teaching or teaching experience.

531. Principles of Instructional Supervision (3) Social and institutional settings for instructional supervision; functions, activities, and practices of supervision; supervisory case studies.

532. Supervision of Student Teachers (3) A course in supervision for master teachers, department heads, and college teachers with supervisory responsibilities in teacher education. Prerequisites: teaching experience and 18 credits in education including at least 5 in methods.

533. Research Problems in the Teaching of Social Studies (3) Historical-philosophical bases for the social studies: curriculum development, research findings and techniques, learning resources and promising proposals. Prerequisites: Sec.Ed. 433 and teaching experience.

537. (Biol. 537) Workshop in the Biological Sciences (3) Projects designed for teachers of biology in the secondary schools.

538. Research Problems in Science Teaching (3) Problems and research dealing with curriculum, materials, evaluation, and supervision of science teaching and learning. Prerequisites: Sec.Ed. 438 and teaching experience.

539. Research Problems in the Teaching of English (3) Cooperative study by specialists, teachers, and administrators of problems and research findings in the teaching of English in American schools. Prerequisites: Sec.Ed. 453 and teaching experience.

546. Seminar on Reading Instruction (3-6) Research procedures and materials in reading readiness, word perception, basic reading skills, vocabulary development, reading in content subjects. Prerequisite: Sec.Ed. 443 or El.Ed. 443.

550. Problems in Modern Secondary Education (3) Historical, psychological, social, and economic factors influencing secondary education. Prerequisite: secondary school teaching.

551. Seminar in Contemporary Issues in the Secondary School Curriculum (2-3) Principles and philosophy of curriculum construction. Each student works out an individual problem in the secondary school curriculum. Prerequisites: 12 credits in education and psychology, and teaching experience.

553. Organization and Administration of the Junior High School (2-3) Problems in reorganization of secondary education, with particular reference to philosophy, organization, and teaching problems of the junior high school. Prerequisites: 12 credits in education and psychology, and teaching experience.

585. Curriculum Construction (2-3) Functions of administrators, supervisors, teachers, pupils, and laymen in curriculum building to meet pupil and community needs.

588. Problems, Projects, and Area Studies in Secondary Education (1-6) Independent work in the study of topics in secondary education or the development of new curriculums, materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of the department head.

594. Seminar in Secondary Education (1-3) Conferences and discussions designed to meet the need for special study of particular fields in secondary education. Prerequisite: 12 credits of graduate work in education.

SLAVIC LANGUAGES AND LITERATURES (S L L)

William R. Schmalstieg
Head of the Department of Slavic Languages
N-440 Burrowes Building

Degree Conferred: M.A.

Graduate Faculty: Senior Members Birkenmayer, Magner, and Schmalstieg.
Graduate Faculty: Associate Member Paternost.

Opportunities for specialization in literature or linguistics are available. A minimum requirement for admission is an undergraduate major in Russian or its equilvalent.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

The department prefers that M.A. candidates in this major submit a term paper rather than a thesis.

RUSSIAN (RUS)

426. Dostoevsky (3)
427. Tolstoy (3)
430. Methods and Materials for Teaching Russian (3)
450. History of the Russian Language (3)
460. Linguistic Analysis of Contemporary Russian (3)
497. Problems in Russian (3-9)

*1G. Technical Russian for Graduate Students (3) Prepares student to translate technical and scientific texts. No previous knowledge of Russian is required.

*2G. Russian Texts (3) Development of skill in translating Russian texts in the sciences and social sciences. Prerequisite: Rus. 5 or 1G.

501. Readings in Russian Literature (3-6) Prerequisite: Rus. 204.

525. Pushkin (3) Pushkin's significance in Russian literature; his relation to other European literatures; *Eugene Onegin* and selected shorter works.

540. Seminar in Old Russian Literature (3) Literary and linguistic analysis of Russian literary monuments in the original, 1100-1800. Prerequisite: Rus. 450.

542. Seminar in Soviet Literature (3-6) Works of representative Soviet writers; individual research in contemporary Soviet literature and literary criticism.

570. Seminar in the Analysis of Old Russian Literary Documents (3-6) Reading, translation, interpretation, and analysis of old Russian literary documents. Texts differ from those read in Rus. 540. Prerequisite: Slav. 550.

SLAVIC (SLAV)

500. Bibliography and Research Techniques (3) Tools and methods of research, designed for students preparing to do independent investigation of problems in Slavic languages and literature.

510. Structure of the South Slavic and West Slavic Languages (3-12; 3 credits per language) Linguistic analysis of a particular South Slavic (Bulgarian, Macedonian, Serbo-Croatian, Slovenian) or West Slavic (Czech, Lusatian, Polish, Slovak) language. Prerequisite: Rus. 460 or one graduate course in linguistics.

550. Old Church Slavic (3) Reading and study of that corpus of religious and liturgical documents representing the first written records of a Slavic tongue.

560. Theory and Technique in Slavic Linguistics (3-6) Analysis of the relationship of the Slavic languages; consideration of particular linguistic problems within one or more of the languages.

* No graduate credit is given for this course.

SOCIAL STUDIES (SO ST)

HUGO A. MEIER
Chairman of the Committee on Social Studies
214 Sparks Building

Degree Conferred: M.Ed.

This program, designed to meet the needs of secondary school teachers, requires at least 24 credits chosen from economics, history, human geography, political science, and sociology. A candidate is expected to complete at least 3 credits each in four of these areas but not more than 12 in any one of them. A minor of at least 6 credits in educational foundations is also required.

For admission a student must have had solid preparation in the basic courses in economics, history, political science, and sociology and should have had some advanced undergraduate work in at least one of these areas. He must also have had 18 credits in education and related psychology, and he should be certified for teaching social studies. Ideally, he should have had teaching experience in this field as well.

Students who present a 2.50 junior-senior average and a 3.00 average in the social studies areas will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

SOCIOLOGY (SOC)

MARGARET B. MATSON, *Acting Head of the Department*
107 Burrowes Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Buck, Clark, DeJong, Matson, Simirenko, Snyder, and Theodorson.

Graduate Faculty: Associate Members Faulkner, Foreman, Raphael, Rath, Sim, and Westby.

The M.A. and Ph.D. programs center around a training in basic social theory and methodology and the empirical findings in the various areas of sociology. Departmental emphases include social psychology, sociological theory, social gerontology, community structure and change, and an interdisciplinary program in population issues. Other areas in which it is possible for students to specialize include complex organizations, political sociology, the sociology of education, the sociology of religion, the family, and methodology and statistics. The program is designed with considerable flexibility so that students can adapt course work outside the department to their individual interests and goals. Work in computer science, philosophy of science, or mathematics may be used to fulfill part of the Ph.D. degree communication and foreign language requirement, but a reading knowledge of a minimum of one foreign language is required. All first-year students who intend to pursue doctoral work are expected to earn an M.A. degree in their normal progress to the Ph.D. The department offers three options leading to the M.A. degree. The choice of program option will be determined by agreement between the student and his adviser. A student has the option to write a thesis or a paper for the M.A. degree.

Undergraduate training in sociology is expected. Students of ability who are deficient in undergraduate preparation may be accepted with provisions to make up course

deficiencies in the early part of their graduate program. Candidate selection is based on the following information: quality undergraduate academic performance, above average Graduate Record Examination scores, letters of recommendation, and an essay giving the applicant's interests, goals, and purposes for graduate work in sociology. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

The population issues program is a course of study focusing on the social, economic, and geographic policy-related issues arising from the dynamics of population trends, especially in developed nations. In addition to departmental admission requirements, the population issues committee evaluates the student's interest and aptitude for the training program which consists of a minimum of 21 credits of interdisciplinary course work in population.

Other areas of study related to sociology, such as rural sociology, community development, cultural anthropology, developmental psychology, and political behavior are offered in other departments of the University.

Special departmental research and training facilities include the Psycho-Social Studies Center, Medical Sociology Research Center, The Liberal Arts Data Laboratory, small groups research laboratory, and a sociology reference library. Additional University facilities used by sociology faculty and graduate students include the Computation Center, the Inter-University Consortium of Political Research, the Institute of Public Administration, the Institute for Research in Human Resources, and the Center for the Study of Religion and Human Resources.

SOCIOLOGY (SOC)

400. Advanced General Sociology (3)
401. Social Institutions (3)
403. Advanced Social Psychology (3)
404. Small Groups (3)
406. Sociological Analysis of Deviance (3)
408. Social Ecology (3)
410. Social Psychology of Health (3)
412. Penology (3)
413. Methods and Techniques of Social Research (3)
415. The Urban Community (3)
416. (C.F.Ed. 416) Sociology of Education (3)
418. The Development of Social Thought (3)
419. Race Relations (3)
422. History of Sociological Theory (3)
423. Social Demography (3)
424. Social Change (3)
426. Public Welfare Policy and Services (3)
427. Social Case Work (3)
428. Seminar in Sociology (1-6)
429. Social Stratification (3)
430. Family in Cross-Cultural Perspective (3)
432. Collective Behavior (3)
435. Social Gerontology (3)
436. (Journ. 436) Sociology of Opinion Formation (3)
438. (Rl.St. 438) Religion and Urban Society (3)
444. Complex Organizations (3)
446. Political Sociology (3)
450. Community Organization (3)
453. (Anthy. 453) Primitive Religion (3)

454. (L.S. 454) Industry and the Community (3)
455. (L.S. 455) Occupations and Professions (3)
456. Readings in Sociology (1-9)
457. (L.S. 457) Field Work in Industrial Sociology (1-6)
461. (Rl.St. 461) Sociology of Religion (3)
470. Intermediate Social Statistics (4)
473. Methods of Demographic Analysis (3-6)
499. Foreign Study in Sociology (2-6)

500. Seminar in Group Theory (1-3) The group as a unit of social structure and action.

502. Theories of Society (3) Past and present theories of the overall structure and processes of societal functioning.

503. Research Seminar in Social Psychology (3-6) Design and conduct of research in areas of mutual interest in social psychology.

504-505. Current Social Theory (3 each) Current contributions to social theory; their relations to each other and to the larger theoretical structure.

506. Seminar in Sociological Theory (3-9)

507. Introduction to Graduate Study in Sociology (1) Required of all incoming graduate students in sociology.

509. Seminar in Medical Sociology Research (1-6) Early and current classics of medical sociology research critically reviewed; limitations and possibilities; needs of society; available resources. Prerequisites: Soc. 410, 413.

510. Field Work in Sociology (1-6)

511. Readings in the Sociology of Health (1-6) Independent pursuit of existing knowledge in fields of the student's interest, in reference books, monographs, journals. Bibliography preparation. Prerequisite: Soc. 410.

512. Seminar in Deviant Behavior (2-6) Advanced sociological study of crime, juvenile delinquency, mental disorders, suicide, drug addiction, prostitution, and other social deviation. Prerequisite: 6 credits in sociology.

513-514. Sociological Methods (3 each) Critical review of methodological issues; philosophy of science; research designs; analysis and interpretation of findings. Prerequisites: Soc. 413, 470.

515. Seminar in Community Studies (3)

518. Research Studies in the Sociology of Education (3) Analyses of the design, methods, and findings of selected classical and current research studies in the sociology of education. Prerequisite: Soc. 416.

523. Seminar in Population Theory and Policy (1-6) Critical review of multidisciplinary population research with an emphasis on its relation to policy issues. Prerequisite: 3 credits in population or human ecology.

525. Seminar in Sociology (1-6) Research problems in theoretical and applied sociology.

529. Seminar in Intergroup Relations (3) Review of research into minority-majority group relations.

530. Research on Marriage and the Family (3) Training in methods and techniques of research in family relations. Experimental, statistical, and comparative

studies are carried out, individually or cooperatively. Prerequisite: 3 credits of previous work in this field.

532-533-534. Social Relations (3 each) Critical appraisal of major social-psychological problems confronting modern man; emphasis on formulation of fruitful research projects and their evaluation. Prerequisite: 15 graduate credits in social science departments or psychology, including a course in statistics.

535. Seminar in Gerontology (2-6) A structural-functional analysis of current research dealing with the relationships between institutional structure, age grading, and social behavior.

*546. Seminar in Political Sociology (3-6) Research and analysis of contemporary issues in political sociology. Prerequisite: 3 credits in statistics.

555. Industrial Sociology (3) Research methods and techniques in industrial sociology; current research, unexplored areas.

572-573. Social Statistics (3 each) Application of parametric and non-parametric statistical methods to sociology; sampling; computer data processing techniques. Prerequisites: Soc. 470 and 3 credits in research methods.

574-575. Quantitative Sociology (3 each) Problems and issues in the mathematical and quantitative aspects of sociology. Prerequisites: Soc. 413, 470.

SOLID STATE SCIENCE (S S S)

Laxman N. Mulay
In Charge of Graduate Programs in Solid State Science
139 Materials Research Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Barsch, Brindley, Cross, Dachille, Henisch, Kline, Knox, McKinstry, Mulay, Newnham, D. Roy, R. Roy, Stubican, Vastola, Vedam, Walker, E. White, and W. White.

Graduate Faculty: Associate Members Johnson, McCarthy, and Spear.

The aim of this intercollege program is to provide an opportunity for the student interested in the structure, properties, and behavior of solid materials to obtain an integrated program of courses encompassing both the necessary fundamentals of chemistry, physics, and mathematics and their technological and engineering applications.

The program of courses taken by a student majoring in this program must necessarily cut across two or more disciplines. The relevant subject matter has been grouped into four areas: (1) the structure of solids (crystal chemistry and structure determination); (2) theory related to the solid state (physics, chemistry, and mechanics); (3) properties of solids (optical, electrical, magnetic, mechanical, thermal, and chemical); and (4) reactions of solids (phase equilibria, reaction mechanisms, reaction kinetics, and surface reactions).

The course work of all students will normally include the "core program" as periodically redefined by the committee. Recommended course sequences for each year for students with different undergraduate backgrounds are prepared by the chairman and are available from the student's adviser. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages or by one foreign language together with courses from other designated areas.

* 3 credits per term.

Entering students should hold a bachelor's degree in chemistry, physics, mathematics, geological science, engineering, ceramics, or metallurgy, or in a closely related field that will have included in it mathematics at least through integral calculus and a minimum of one year of physics and one year of chemistry. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. The applicant should be interested specifically in an interdisciplinary program of study and research. Thesis research on various aspects of the solid state may be conducted in the Materials Research Laboratory, the Ordnance Research Laboratory, or in appropriate departments in the Colleges of Earth and Mineral Sciences, Engineering, and Science. The experimental facilities for research in several aspects of materials science and engineering are exceptional.

S.S.S. 500 (seminar) and S.S.S. 590 (special research problems) will be offered to promote the interdisciplinary aspects of solid state science. Further information will be available from the S.S.S. office.

In addition, students may select appropriate course work from any engineering or science department. The following list includes those which are most commonly taken to satisfy the requirements: Structure of Solids: Chem. 516, Gchem. 512; Min. 463, 500. Solid State Theory: Chem. 544, 545, 565, 566, 567; E.Mch. 507, 516, 531, 540; Metal. 514; Phys. 410, 412, 470, 512-513, 517, 561-562, 571. Physical Properties of Solids: Cer.Sc. 506, 507, 508; Chem. 455; E.Mch. 414, 506, 530, 533, 546; Metal. 516; Nuc.E. 509. Chemical Reactions in Solids: Cer.Sc. 503, 504, 511, 512; Chem. 563; F.Sc. 506; Gchem. 513, 520; Mat.Sc. 411A, 411B, 411C, 411D, 420, 421, 512, 514, 570; Metal. 508, 515, 518, 522; Min. 531, 532, 533, 535, 538, 540; Plm.Sc. 406, 407, 408, 409, 410, 560, 562.

SPANISH (SPAN)

Martin S. Stabb
Head of the Department of Spanish, Italian, and Portuguese
N-352 Burrowes Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty: Senior Members Brentin, Dalbor, Lima, Moser, Perez, Stabb, and Sturcken.

Graduate Faculty: Associate Members Halsey, Lyday, Ramos, and Triolo.

The minimum requirement for admission will normally be 24 credits of postintermediate work in Spanish language and literature. A student may specialize in either the area of literature or descriptive and historical linguistics. The department may waive the requirement of a thesis for M.A. candidates in this major.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages or by comprehensive knowledge of one.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

SPANISH (SPAN)

400. Advanced Grammar and Composition (3)
404. The Evolution of Spanish (3)
410. Advanced Oral Expression and Communication (3)
413. The Teaching of Spanish (4)
414. Spanish Phonology (3)
415. Spanish Morphology and Syntax (3)
416. Old Spanish Literature (3)
426. The Golden Age (3)
427. Drama of the Golden Age (3)
439. Don Quijote (3)
459. The Generation of 1898 (3)
472. The Contemporary Spanish-American Novel (3)
475. Introduction to Latin-American Literature (3)
476. Introduction to Latin-American Literature (3)
477. The Literature of Mexico (3)
480. Literature of Argentina (3)
482. Spanish Lyric Poetry (3)
483. Spanish Drama of the Nineteenth Century (3)
485. Spanish Drama of the Twentieth Century (3)
487. The Spanish Novel of the Nineteenth Century (3)
489. The Spanish Novel of the Twentieth Century (3)
497. Problems in Hispanic Literature (3-12)
499. Foreign Study in Spanish (3)

502. Theory and Techniques of Teaching Spanish (1-3) Audio-lingual orientation. *Mr. Dalbor*

503. Methods and Bibliography in Spanish (1-3) Methods of research; evaluation of sources and materials. *Mr. Brentin*

505. Old Spanish: Phonology, Morphology, and Syntax (3) *Mr. Sturcken*

506. History of the Spanish Language (3) *Mr. Sturcken*

507. Hispano-Romance Linguistics (3) *Mr. Sturcken*

510. Spanish Descriptive Linguistics: Phonology (3) *Mr. Dalbor*

511. Spanish Transformational-Generative Linguistics (3) *Mr. Dalbor*

514. Hispanic Dialectology (3) Early fragmentation among the peninsular dialects; origins and descriptive analysis of the American dialects; Judeo-Spanish. *Messrs. Sturcken and Dalbor*

515. Medieval Spanish Nonepic Literature (3) *Mr. Sturcken*

516. Medieval Spanish Epic Poetry and Prose (3) The *Poema de Mio Cid;* origins and diffusion of epic themes; their influence through the *crónicas,* the *Romancero,* and later literature. *Mr. Sturcken*

518. El Libro De Buen Amor (3) *Mr. Sturcken*

521. The Celestina and the Literature of the Spanish Pre-Renaissance (3) Chief trends and works of the period of the Catholic Monarchs with special emphasis on Fernando de Rojas' masterpiece *La Celestina. Messrs. Triolo and Pérez*

525. Spanish Renaissance and Golden Age Poetry (3) Lyric poetry, epic poetry, and balladry. *Mr. Triolo*

527. Sixteenth-Century Spanish Prose (3) The major prose writers of the Spanish sixteenth century. *Messrs. Brentin and Pérez*

528. Seventeenth-Century Spanish Prose (3) Various types of novels of the seventeenth century, with special emphasis on the picaresque, didactic literature, histories. *Messrs. Brentin and Pérez*

538. Theatre of Lope De Vega and His Cycle (3) Major works of Lope de Vega, Tirso de Molina, Buillen de Castro, Mira de Amescua, and others. *Mr. Pérez*

539. Theatre of Calderón De La Barca and His Cycle (3) Major works of Calderón de la Barca, Rojas Zorrilla, Augustin Moreto, and others. *Mr. Pérez*

540. Cervantes: The Quijote (3) A careful reading of Cervantes' famous novel and consideration of some of the corpus of criticism on the novel. *Messrs. Pérez and Brentin*

541. Cervantes: Other Works (3) Cervantes' major works, excluding the *Quijote.* *Messrs. Brentin and Pérez*

544. Spanish Romanticism (3) The major authors and works of peninsular romanticism, including poetry, drama and prose. *Miss Halsey and Mr. Lima*

550. Spanish Realism (3) The major figures of the period with special emphasis on Pérez Galdós. *Mr. Ramos*

554. Generation of 1898: Prose (3) Selected essays and novels from the works of Ganivet, Pidal, Unamuno, Maeztu, Azorin, Lanza, Baroja and Valle-Inclán. *Messrs. Lima and Ramos*

555. Generation of 1898: Poetry and Drama (3) Selected poems and plays from the works of Antonio and Manuel Machado, Benavente, Grau, Azorin, Valle-Inclán, Unamuno, Baroja and others. *Mr. Lima*

560. The Contemporary Novel in Spain (3) The novel since 1941: Cela, Laforet, Zunzunegui, Suárez Carreño, Matute, and others. *Messrs. Brentin and Ramos*

563. Contemporary Drama in Spain (3) The drama since 1898 to the present day: Benavente, Valle-Inclán, Garcia Lorca, Casona, Buero Vallejo, Sastre, and others. *Miss Halsey and Mr. Lima*

566. Contemporary Spanish Poetry (3) Various currents in Spanish poetry from the Generation of 1927: Lorca, Aleixandre, Salinas, Guillen, Alonso, Alberti, Hernandez, Otero and others. *Mr. Brentin*

570. Modernismo (3) The movement, its antecedents, and its followers, with special emphasis on Rubén Darío. *Mr. Moser*

572. Spanish-American Novel of the Nineteenth and Early Twentieth Century (3) Evolution of the genre and representative works. *Messrs. Stabb and Lyday*

573. The Contemporary Spanish-American Novel (3) Evolution of the genre since 1940 and representative novelists. *Mr. Stabb*

575. The Spanish-American Essay (3) Tracing the history of ideas in Spanish America through major essayists. *Messrs. Stabb and Moser*

576. Twentieth-Century Spanish-American Poetry (3) Influential poets and literary movements after *Modernismo.* *Messrs. Lyday and Stabb*

577. Spanish American Drama (3) Dramatic literature in Spanish America from colonial times to the present. *Mr. Lyday*

579. Colonial Literature (3) Transplantation of European culture to Spanish America, literary genres cultivated in the colonies, and principal writers. *Mr. Moser*

581. The Spanish-American Short Story (3) Critical analysis of the major writers and movements from Echeverría to the present. *Messrs. Stabb and Lyday*

584. Spanish American Romanticism (3) The principal writers and tendencies of the Romantic movement in Spanish America. *Mr. Moser*

587. Stylistic and Literary Criticism (3) Major theories of literary criticism applied to Hispanic literature. *Staff*

588. Seminar in Hispanic Literature (3-12) Common and individual research in special problems in Spanish or Spanish-American literature. *Staff*

SPEECH (SPCH)

Herman Cohen, *Head of the Department*
305 Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.A.

Graduate Faculty: Senior Members Arnold, Borden, Brubaker, Cohen, Fife, Frandsen, Gregg, Holtzman, Nelson, Paulson, Phillips, and White.

Graduate Faculty: Associate Members Benson, Butt, Dunham, Hauser, Hungerford, and Preston.

The student may specialize in speech arts (interpretation, drama, theatre); radio and television; rhetoric and public address (including discussion, communication, teaching of speech); speech science (voice, diction, phonetics, general semantics); communicative theory; or international communication. A thesis is required of all M.A. candidates in this major.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign languages.

The minimum undergraduate preparation required is 12 credits in speech. Students who cannot meet this requirement in full may be admitted but must make up their deficiencies without credit toward the graduate degree. Spch. 400 and 502 are required of all graduate students who do not have their equivalents.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

SPEECH (SPCH)

400. Teaching of Speech (3) *Mr. Butt*
402. Speech and Human Behavior (3) *Mr. Phillips*
403. Interpersonal Oral Communication Theory (3)
410. English Phonetics and Pronunciation (3) *Mr. Brubaker*
412. Speech Criticism (3) *Mr. Arnold*
417. Directing Forensics (3) *Mrs. Lutz*
419. (Journ. 419) Comparative Broadcasting Systems (3) *Mr. Hungerford*

420. History of Rhetorics (3)
425. Radio Programming and Performance (3) *Miss Preston*
431. Anatomy and Physiology of the Ear and Vocal Mechanisms (3) *Messrs. Brubaker and Gilbert*
435. Radio and Television Programming (3) *Mr. Nelson*
437. Television Programming and Performance (3) *Mr. Hungerford*
440. Speech-Communication: Research and Theory (3) *Mr. Frandsen*
450. Discussion: Research and Theory (2-6) *Messrs. Butt and Phillips*
470. Nonverbal Communication (3) *Messrs. Benson and Frandsen*
475. Studies in Mass Persuasion in the Democratic Society (3) *Messrs. Gregg and Hager*
478. Contemporary Public Address: English and American Speakers (2) *Mr. Gregg*
480. Computer Applications in Speech Studies (3) *Mr. Borden*
485. Advanced Oral Interpretation of Literature (3) *Mr. Wigley*
489. Directed Study (1-6) *Staff*
490. Psychology of Speaking and Listening (3) *Mr. Holtzman*
494. Teaching of English as a Second Language (3) *Mr. Holtzman*
496. Speech for Teachers (3) *Mr. Butt*

500. Seminar in American Oratory (2-6) History of American oratory with application of critical standards to the work of specific orators. *Mr. White*

502. Research Methods in Speech (3) Research design, thesis proposals, and background for research in graduate study. Prerequisite: 6 credits at the 400 or 500 level in speech, clinical speech, or theatre arts. *Staff*

505. Historical Development of Speech Theory and Criticism (2-4) Classical theories of speech-making from the earliest beginnings to the fall of the Roman Empire. *Mr. Arnold*

506. Historical Development of Speech Theory and Criticism (2-4) Theories of speech-making from the Renaissance to the present. *Mr. Arnold*

508. Seminar in British Oratory (2-4) History of British oratory; application of critical standards to the work of selected orators. *Miss Fife*

509. Problems in Rhetoric and Oratory (2-6) Comparative study of selected orators and rhetoricians. Prerequisite: 6 credits in speech. *Mr. Gregg*

510. Problems in Speech Education (2-4) Advanced knowledge, theories, and principles, together with their philosophical, scientific, clinical, artistic, and educational implications for the teacher of speech. Prerequisite: Spch. 502 and 9 additional credits at the 400 or 500 level in speech, clinical speech, or theatre arts. *Mr. Phillips*

520. Seminar in Speech Science (3-6) Seminar in physical and physiological bases of speech and voice; introduction to laboratory techniques used in speech research. Prerequisite: 9 credits in speech, speech pathology and audiology, or psychology. *Messrs. Brubaker and Gilbert*

530. Political Speaking in the Broadcast Media (3) Study and research of the principles of speaking as they are employed for political purposes when utilizing the broadcast media. *Mr. Nelson*

540. Seminar in Problems of Television and Radio (2-4) Study and research in television and radio as they pertain to programming, production, relation to society, and speech. *Mr. Nelson*

550. Seminar in Oral Persuasion (2-4) Theory and devices of persuasion; analysis of persuasive discourse. Prerequisite: 6 credits in speech including Spch. 200. *Messrs. Holtzman and Frandsen*

552. Oral Communication in Industry, Business, and Government (2-4) Needs, practices, and methods in American industry, business, and government; methods of training adults in oral communications skills. *Mr. Frandsen*

554. Seminar in Small Group Communication (2-4) Communication variables in small groups. Experimental research and innovations in communication in vocational, therapeutic, and educational groups. *Mr. Phillips*

555. Speech Communication: Problems and Principles (2-6) Prevalent theories of speech influence. *Messrs. Borden, Phillips, and Frandsen*

564. Seminar in European Oratory (2-4) Analysis of significant European speeches with consideration of cultural influences on invention and style. Prerequisite: 6 credits in speech. *Staff*

575. Research Problems in Speech (1-9) Advanced research on an individual basis in oratorical criticism, discussion techniques, persuasion, pedagogy, phonetics, speech science, and speech pathology. Prerequisite: 12 credits in speech or speech pathology and audiology. *Staff*

SPEECH PATHOLOGY AND AUDIOLOGY (S P A)

Bruce M. Siegenthaler
In Charge of Graduate Programs in Speech Pathology and Audiology
110 Psychology Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Frick, McDonald, Michael, and Siegenthaler.
Graduate Faculty: Associate Member Berlin.

Students may specialize in speech pathology, audiology, or education of the deaf. The programs include the requirement of a number of field trips to diagnostic and treatment facilities and may include a period of internship at an off-campus location. Students should expect to have moderate expenses related to these trips.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign languages. The nonthesis option is available for the M.S. degree.

Required are 24 credits distributed among speech pathology, audiology, speech science, psychology, and related areas (including one statistics course, tests and measurements for education of the deaf) and letters of recommendations. Students entering without an undergraduate program in the field may be required to take additional make-up courses.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the grade-point average may be made for students with special backgrounds, abilities, and interests.

SPEECH PATHOLOGY AND AUDIOLOGY (S P A)

430. Introduction to Audiology (3)
433. Methods in Auditory Training and Speech Reading (3)
434. Pure Tone Audiometry (3)
439. Practicum in Auditory Training and Speech Reading (1-5)
440. (E.E.C. 440) Survey of Speech and Hearing Disorders (3)
441. Current Problems in Speech Pathology and Audiology (1-6)
442. Speech Pathology: Articulation and Stuttering (3)
444. Speech Pathology: Voice and Organic Disorders (3)
445. Professional Programs and Relationships (3)
449. Practicum in Speech Therapy (1-6)
460-461. Teaching Speech to the Deaf (2 each)
462-463. Teaching Language to the Deaf (3 each)
464-465. Teaching Elementary School Subjects to the Deaf (2 each)
466. Problems in Education and Guidance of the Deaf (3)
467. Audiology for Teachers of the Deaf (3)
469. Student Teaching with the Deaf (3-12)

530. Seminar in Audiology (1-6) Review of theories of hearing and review of related physiological and psychological researches. Prerequisite: S.P.A. 434.

531. Speech Audiometry and Hearing Aids (3) Techniques and interpretation of speech reception tests; hearing aids and hearing aid advisement procedures; observations and practice in test administration. Prerequisite: S.P.A. 434.

532. Acoustical Instruments for Hearing (3) Acoustical instrumentation used for research in hearing, programs of hearing conservation, and noise control, including clinical and industrial applications. Prerequisite: 6 credits in acoustics, audiology, experimental psychology, or speech science at 400 level.

534. Noise and Hearing (3) Noise induced hearing problems; interference with communication; annoyance and community problems caused by acoustic energy; regulations and standards. Prerequisite: 6 credits at 400 level in acoustics, audiology, experimental psychology, or speech science.

538. Practicum in Audiologic Evaluation and Selection of Hearing Aids (1-5) Prerequisite: S.P.A. 531.

540. Articulation Disabilities (3) Speech-sound production disorders in children and adults; methods of examination, diagnosis, and treatment. Prerequisites: S.P.A. 442, 449.

541. The Voice and Its Disorders (3) Physical, physiological, and psychological bases of voice production; causes, nature, and symptoms of its disorders; current clinical methods in voice improvement. Prerequisites: S.P.A. 444, 449.

542. Stuttering (3) Modern theories of causes of disorders of rhythm; methods of examination, diagnosis, and treatment. Prerequisites: S.P.A. 442, 449.

543. Diagnostic Procedures in Clinical Speech (3) Clinical instrumentation; case history taking; examination procedures and materials used in diagnosing speech disabilities; interpretation of findings; report preparation. Prerequisite: S.P.A. 444.

544. Cleft Palate (3) Anatomy, physiology, embryology, and growth of the palate and contiguous structures; etiology, diagnosis, habilitation of cleft palate problems. Prerequisite: S.P.A. 444.

545. (E.E.C. 545) Cerebral Palsy (3) Etiology and symptomatology of cerebral palsies; diagnosis and treatment of communication problems; the multi-professional habilitative program. Prerequisite: S.P.A. 444.

546. Language Disorders in Adults (3) Nature, etiology, diagnosis, and management of language disorders in adults. Prerequisite: 9 credits S.P.A. or related fields such as psychology, linguistics, or human development.

547. (E.E.C. 547) Language Disorders in Children (2) Nature, etiology, diagnosis, and management of language disorders in children. Prerequisite: 9 credits in speech pathology and audiology or related fields such as psychology, linguistics, or human development.

548. Practicum in Speech Diagnosis (1-3) Supervised practice in interviewing, counseling, speech evaluation, and synthesis of psychological medical and audiological data in speech diagnosis; report writing. Prerequisites: S.P.A. 444, 449.

549. Advanced Practicum in Speech Therapy (1-6) Theoretical and clincial rationale of therapy; professional role and relationships; therapy procedures, individual and group; evaluation of process and outcomes. Prerequisites: S.P.A. 442, 449.

550. Seminar in Speech Pathology (1-6) Advanced study of special problems and new developments in speech pathology. Prerequisites: S.P.A. 442, 444.

560. Recent Developments in Education of the Deaf (2-6) In-depth seminar style study of communication disorders associated with deafness, and advanced and experimental attempts at remediation. Prerequisites: 8 credits in education of the deaf or audiology, S.P.A. 430 and 433, and 3 credits in child development or learning theory.

STATISTICS (STAT)

William L. Harkness, *Head of the Department*
333 McAllister Building

Degrees Conferred: Ph.D., M.A., M.S.

Graduate Faculty: Senior Members Antle, Bartoo, Haight, Harkness, Hultquist, Joiner, and Patil.

Graduate Faculty: Associate Members Boswell, Hettmansperger, Kappenman, and Klimko.

Graduate instruction and research opportunities are available in most areas of probability and statistics, including experimental design, linear models, multivariate analysis, nonparametric statistics, analysis of counted data, computerized data analysis, distribution theory, stochastic processes (applied and theoretical), various areas in probability theory, and statistical ecology.

For the M.A. degree the candidate must complete 30 course credits, with at least 18 credits (15 in statistics) of 500-level courses, Math. 421, and Math. 441 or 481 in addition to a term paper. For the M.S. degree, 12 credits of 500-level statistics courses, 6-9 credits of thesis, Math. 421, and Math. 441 or 481 are required.

Ph.D. candidacy is contingent upon passing certain specified qualifying examinations. The communication and foreign language requirement for the Ph.D. degree is flexible, requiring none, one, or two foreign languages, depending on the individual's program; if less than two languages are allowed, appropriate substitutions involving interdisciplinary work that leads to the development of a strong area of

application and/or computer science may be required. Emphasis is placed on helping the student expand his creative ability to solve real problems having statistical aspects.

While applications from all students (including those who already have done graduate work) are reviewed, completion of a standard calculus sequence is regarded as a prerequisite. Students with a 3.00 or better junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

STATISTICS (STAT)

401. Experimental Methods I (3)
402. Experimental Methods II (3)
403. Experimental Methods III (3)
409-410. (Math. 409-410) Introduction to Mathematical Statistics (3 each)
412. (Math. 412) Introduction to Mathematical Statistics (3)
418. (A.M. 418, Math. 418) Discrete Probability Theory (3)
427. (Math. 427) Discrete Stochastic Models (3)
451. Statistical Methods I (3)
452. Statistical Methods II (3)
453. Statistical Methods III (3)
461. Sampling Methods (3)
462. Applied Regression Analysis (3)
463. Applied Multivariate Analysis (3)
464. Applied Nonparametric Statistics (3)
490. Special Topics in Probability and Statistics (3-9)

501. Multivariate Distribution Theory (3) Sufficiency and completeness, testing hypotheses, sequential analysis, chi-square tests, analysis of variance. Prerequisite: Stat. 410.

502-503. Analysis of Variance and Regression (3 each) Linear hypotheses, regression, analysis of variance and covariance, mixed and random effects models, multiple comparisons, designs. Prerequisites: Stat. 410; Math. 441 or 481.

504. Nonparametric Statistics (3) Asymptotic and finite distribution theory, asymptotic efficiency, rank tests for location and dependence. Prerequisites: Stat. 410 and 3 additional credits in statistics.

505. Multivariate Statistical Analysis (3) Statistical procedures associated with the multivariate normal distribution. Prerequisites: Stat. 501; Math. 441 or 481.

506. Sampling Theory (3) Theory and application of sampling from finite populations. Prerequisite: 6 credits in statistics.

507. Sequential Analysis (3) A thorough discussion of sequential procedures of estimation and testing of hypotheses. Prerequisite: Stat. 410.

508. Characterization of Statistical Models (3) Characteristics of different statistical distributions; characterizations of distributions through structural properties and statistical procedures. Prerequisite: 543.

509. Discrete Statistical Models and Methods (3) Systematic study of probability models and statistical methods pertaining to statistical analysis of data consisting of single and multiple counts. Prerequisite: Stat. 554.

512-513. (A.M. 512-513) Introduction to Stochastic Processes (3 each) Markov chains, random walk and recurrent events, queuing theory, time-dependent stochastic processes. Prerequisite: Stat. 418.

517-518. (Math. 517-518) Probability Theory (3 each) Measure theoretic foundation of probability, distribution functions and laws, types of convergence, central limit problem, conditional probability, special topics. Prerequisites: Math. 452, 501.

524. Ecometrics (3) Stochastic models and statistical methods in ecological problems; population dynamics, spatial patterns in populations of one, two or more species. Prerequisite: Stat. 409 or 418.

528. Queuing Models in Transportation (3) Arrival patterns, the service mechanism, queue discipline, delays, multiple queues, problems involving interrupted flow, multiflow routes.

542-543. (Math. 542-543) Statistical Distribution Theory (3 each) Random variables and expectations; discrete, continuous, univariate, multivariate, exact, and asymptotic distribution theory. Prerequisites: Math. 421 and 441 or 481.

553. Statistical Estimation and Testing I (3) Point estimation of one parameter; sufficiency; completeness; maximum likelihood; interval estimation. Prerequisite: Stat. 543.

554. Statistical Estimation and Testing II (3) Neyman-Pearson theory and lemma; uniformly most powerful tests; unbiased tests; large sample procedures. Prerequisite: Stat. 553.

558-559. (Math. 558-559) Theory of Stochastic Processes (3 each) Stationary, independent, and orthogonal processes, discrete and continuous Markov processes, martingales and semi-martingales applications. Prerequisite: Stat. 518.

561. Statistical Inference I (3) Multiparameter estimation; linear estimation; maximum likelihood estimation; Bayesian estimation; large sample properties and procedures. Prerequisite: Stat. 554.

562. Statistical Inference II (3) Testing statistical composite hypotheses; invariance principles; Bayesian statistics; large sample properties and procedures. Prerequisite: Stat. 561.

572. Statistical Decision Theory I (3) Structure of statistical games; optimal strategies, fixed sample-size games. Prerequisites: Math. 502, Stat. 561.

573. Statistical Decision Theory II (3) Sufficient statistics; the invariance principle; estimation and testing. Prerequisite: Stat. 572.

577. (Math. 577) Special Topics in Probability (3-12) Special topics in probability which are not offered regularly but which are of special interest to faculty and students.

591. (Math. 591) Seminar in Probability Theory (1-6) Lectures on current and recent research in various special topics in probability theory.

592. Special Topics in Statistics (3-12) Special topics in statistics which are not offered regularly but which are of special interest to faculty and students.

THEATRE ARTS (THEA)

DOUGLAS N. COOK, *Head of the Department*
103 Visual Arts Building

Degrees Conferred: M.A., M.F.A.

Graduate Faculty: Senior Members Manfull, Smith, Walters, and Yeaton.
Graduate Faculty: Associate Members Allison and Cook.

The M.A. program is planned to provide breadth of studies in theatre. A thesis in some area of specialization is required.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Requirements for admission to the M.A. program are:

1. A broad undergraduate preparation in theatre, including courses in basic acting, directing, theatre crafts, and theatre history (or their equivalents as indicated by evidence or practical experience in the theatre).
2. Eighteen credits in related subject areas, such as oral interpretation, dramatic literature, music, and art.

The M.F.A. program is planned to provide a professional emphasis. Specialization in the following areas is stressed: performance (acting or directing); production (scene design, costuming, lighting, or technical direction); or playwriting. A required final project in the area of specialization includes a monograph.

Requirements for admission to the M.F.A. program are:

1. Twenty-four credits in theatre arts, including one course each in acting, directing, and theatre crafts. Related courses in the student's area of specialization may be accepted.
2. All students are to submit evidence of ability in their areas of specialization under arrangements to be made with the department. Auditions, prompt books, portfolios, manuscripts, and other appropriate presentations are to be submitted by applicants to the various study programs.
3. Vitae and letters of recommendation (at least three) are to be submitted.
4. Personal interviews should be arranged by all students.

All students in the M.A. and M.F.A. programs who are deficient in the required undergraduate courses may be requested to take additional course work in the areas of deficiency without degree credit.

Under certain circumstances the Ph.D. degree is offered by the Department of English with specialization in drama and minor work in theatre arts.

All graduate majors are required to participate in University Theatre productions in positions of responsibility.

401. HISTORY OF ANCIENT AND MEDIEVAL THEATRE (3)
402. HISTORY OF RENAISSANCE AND ORIENTAL THEATRE (3)
403. HISTORY OF MODERN EUROPEAN AND BRITISH THEATRE (3)
405. HISTORY OF AMERICAN THEATRE (3)
410. CREATIVE DRAMATICS WITH CHILDREN (3)
411. PROJECTS IN CREATIVE DRAMATICS (2)
416. CHILDREN'S THEATRE (3)
417. STAGING THEATRE FOR CHILDREN (3)
418. MARIONETTES AND PUPPETRY (3)
424. DANCE FOR THE THEATRE (3)

425. Dance for the Contemporary Musical Theatre (2-6)
427. Theatre Makeup (2)
429. Theatre Performance Practicum (1-6)
434. Directing (3)
435. Rehearsal Methods for the Director (3)
436. Central Staging (3)
445. Advanced Playwriting (3-6)
450. Advanced Scene Design (3-6)
460. Costume Design (3)
461. Costume Construction (3)
462. Drafting Historical Costumes for the Stage (3)
474. Stage Lighting (3)
479. Stage and Production Management (3)
489. Theatre Production Practicum (1-3)
485. Sound for Theatre Production (3)
490. Motion Picture Techniques (3-6)
491. The European Film (3)
492. The American Film (3)
495. Performance for the Camera (3)
496. Radio and Television Directing (3)

500. Theatre Research: Sources and Procedure (1) Materials and techniques as applied to theatre research; the form and content of theses and monographs.

503. Theatre Criticism and Theory (3)

505. Theatre History (3) Specific aspects of theatre from ancient times to the present.

522. Acting I (4) Interpretation of theatrical styles: the tradition of tragedy; voice and movement.

523. Acting II (4) Interpretation of theatrical styles: the tradition of comedy; voice and movement. Prerequisite: Thea. 522.

524. Acting III (4) Interpretation of theatrical styles: forms of modern realism; voice and movement. Prerequisite: Thea. 523.

525. Acting and Directing Theory (3) The actor and director as related to cultural environment from the Greek theatre through the post-Stanislavskian theorists.

530. Play Interpretation for the Director (3) Theory and practice in the analysis and implementation of story, style, and form.

531. Special Forms in Directing (3) Applied theory and techniques for various genres and periods of drama. Prerequisite: Thea. 530.

533. Projects in Directing (1-6 per term)

535. Experimental Theatre (1-3) Operational research and experimental methods in the preparation, planning, execution, observation, and evaluation of production.

540. Playwriting (3-6) Focus on problems in writing the full-length script through seminar, play reading, and individual session.

543. Projects in Playwriting (1-9) Preparation of the script for revision during and rewriting following production of the student's original play. Prerequisite: production approval.

553. Design and Technical Production (1-6 per term) Special projects in design and technical execution of scenery, costumes, lighting, sound, and special effects.

560. Costume Design (3-6) Design concepts, rendering, and execution of costumes for the stage.

574. Lighting for Theatre Production (3) Design techniques for production in arena, thrust, and proscenium theatre situations.

580. Theatre Technology (3) Design consultation and specification of equipment, systems, and movable structures for new theatres; structures and projection devices for production.

582. Theatre Administration (3) The theatre: organization and management.

583. Projects in Theatre Administration, Management, and Operations (1-6)

585. Theatre Planning (3) Processes and problems in planning and designing theatres: performance, audience, and technical requirements.

591. Special Problems in Film and TV (1-3 per term)

VETERINARY SCIENCE (V SC)

Alfred L. Bortree, *Head of the Department*
115D Animal Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Bortree, Dunne, Gentry, Glantz, and Rothenbacher.

Graduate Faculty: Associate Members Eberhart, Kradel, Scholz, Swope, and Zarkower.

Areas of specialization include veterinary pathology, veterinary physiology, and veterinary microbiology. There is opportunity for cooperative research with other departments in animal science, microbiology, and physiology. Unless excused by specific departmental action, all doctoral candidates must attain the master's degree as a step toward candidacy for the Ph.D. degree. A thesis is required of all candidates for the M.S. degree.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by proficiency in reading one foreign language. In the case of foreign students whose native language is other than English, this requirement may be waived with the approval of the doctoral committee.

Prerequisites for admission are a veterinary degree or a bachelor's degree in a related biological field. Adequate preparation in the basic sciences compatible with the candidate's objectives is required. Students may be admitted with limited deficiencies and are required to remove undergraduate deficiencies without degree credit.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. Academic records of candidates with the Doctor of Veterinary Medicine degree or M.S. degree will be reviewed and acted on by the graduate faculty of the department.

VETERINARY SCIENCE (V SC)

401. Ecology of Animal Disease (3) *Mr. Kradel*
405. Laboratory Animal Science (3) *Mr. Murphy*
418. Methods of Animal Cell Culture (3) *Mr. Patton*
420. General Animal Pathology (3) *Mr. Dunne*

520. Histopathology (3) Specific microscopic alterations and reactions developing in the living animal body when exposed to injurious agents or deprivations. *Mr. Rothenbacher*

525. Mechanisms of Hypersensitivity and Immunopathology (3) Concepts of hypersensitivity and special consideration of immunopathological conditions. Prerequisites: Biol. 437, Micrb. 410, and 3 credits of pathology. *Mr. Zarkower*

528. Diagnostic Pathology (3-9) Gross examination of animals and birds, their tissues and body fluids for pathologic changes. Prerequisites: 6 credits in pathology, microbiology, or infectious diseases.

535. Acquired and Congenital Disorders of Metabolism (3) Abnormalities and alterations in metabolism due to dysfunctions of animal organs. Prerequisites: 6 credits in general biochemistry and 3 credits in animal physiology. *Mr. Scholz*

581. Seminar in Veterinary Science (1-4) Presentation and critical discussion of results of personal research or topics of current interest.

582. Special Problems (1-9) Investigation of special disease problems, including laboratory and field studies.

VOCATIONAL INDUSTRIAL EDUCATION (VI ED)

Robert L. Lathrop
In Charge of Graduate Programs in Vocational Industrial Education
240 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Brandon and Gillie.
Graduate Faculty: Associate Members Brantner, Kapes, Long, and Williams.

Emphasis may be placed upon preparation for teaching, supervision, administration, research, or teacher education. The primary focus of the program is preparation for entry into responsible positions within the broadly conceived field of vocational education.

The communication and foreign language requirement for the Ph.D. degree may be met by the successful completion of selected courses in statistics and computer programming.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

INDUSTRIAL EDUCATION (I ED)

402v. Supervision of Vocational Education (3)

403v. Supervised Field Work (6)
408v. Occupations (3)
409v. Tests and Measurements (3)
412v. Special Problems in Vocational Education (6)
415v. Problems in Coordinating Vocational Education (3)
420v. Occupational Hygiene (3)
427v. Advanced Course of Study Building (3)
446v. Improvement of Instruction in Vocational Education (4)
450v. Shop Layout and Management (3)

501v. Seminar in Vocational Education (6) Conferences, investigations, and discussion for advanced students and mature persons who have had experience as teachers, supervisors, or administrators.

506v. Administration of Vocational Education (3) The job of the local director of industrial education in organizing and developing city and other local programs of industrial education. Prerequisite: 6 credits in industrial education, valid director's certificate, or equivalent training and experience.

510v. Vocational Education for Administrators (3) Designed for school administrators and supervisors who desire an understanding of practical arts and vocational education. Prerequisite: I.Ed. 1v or trade or teaching experience.

550v. Research in Vocational Education (3) Research techniques in vocational industrial education.

556v. Federal Legislation (2-3) Recent federal legislative activities and executive orders that bear directly and indirectly upon industrial education.

557v. Present-Day Local, Personnel, and Curriculum Problems (2-3) Various plans, techniques, and practices.

558v. State and Local Supervision and Administration (2-3) The more important recent problems in organization, supervision, and administration.

559v. Vocational Technical Education (2-3) Problems of organization and administration of programs of technical education at the secondary and post-secondary levels. Prerequisite: 6 credits in industrial education, valid director's certificate, or equivalent training and experience.

560v. Philosophy of Industrial Education (3) Principles and beliefs of progressive industrial education; literature for evaluating instructional practices. Prerequisite: 12 credits in industrial education or teaching experience.

WILDLIFE MANAGEMENT (W L M)

Wilber W. Ward, *Director of the School of Forest Resources*
101 Ferguson Building

Degree Conferred: M.S.

Programs are designed to prepare students for positions in wildlife research and management. Specialized training may be directed toward animal ecology, nutrition, physiology, behavior, or pathology.

Applicants should present a minimum of 12 credits in mathematics including at least 6 credits in statistics and/or computer science, 15 credits in chemistry and physics, and 33 credits in biological sciences including courses in forestry or wildlife. Students with a 2.50 junior-senior average and with appropriate course backgrounds

will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

WILDLIFE (WILDL)

408. Mammalogy (3)
446. Wildlife Ecology (3)
447. Wildlife Management (3)
492. Field Research Techniques (3)
493. Laboratory Research Techniques (2)
497. Problems in Wildlife (1-3)

ZOOLOGY (ZOOL)

Joseph G. O'Mara, *Head of the Department of Biology*
208 Life Sciences I Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Anthony, Bellis, Butler, Cheng, Cooper, Dalton, Dunson, Gaffney, Hale, Hibbard, Hymer, Wickersham, and Williams.

Graduate Faculty: Associate Members Abplanalp, Hollis, Mitchell, and Neff.

This program offers emphasis in animal behavior, cell biology, developmental biology, ecology, endocrinology, fishery biology, genetics, histology, ichthyology, invertebrate zoology, morphology, physiology, or population dynamics.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

The bachelor's program must show emphasis on zoological subjects and include adequate preparation in mathematics and physical sciences. Each applicant must provide Graduate Record Examination scores, letters from two persons most familiar with his academic qualifications, and a personal statement of his primary interests and objectives.

A limited deficiency may be made up without degree credit while pursuing graduate work. Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests.

See also Genetics and Physiology.

Note: *For courses in Zoology and related subjects see Biology.*

OTHER ELECTIVE GRADUATE COURSES

The following courses are in fields in which neither major nor minor work is offered at this institution. The courses, however, carry graduate credit and, with the approval of the major department, may be applied toward the requirements for a degree either as elective courses or as a part of a general studies program. The usual restrictions upon the use of 400 series courses in degree programs apply to these courses.

AGRICULTURE, GENERAL (AG)

400. Introductory Biometry (3) *Mr. Bennett*

AMERICAN STUDIES (AM ST)

402. Seminar in American Studies (3-9)

501. Theory and Methods of American Studies (3) Theory and methods for the analysis of American culture: history of ideas, analysis of myth and symbol, comparative arts, etc.

502. Problems in American Studies (3-6) A variable-content course, addressed each term to a specific problem, topic, or period in American culture.

ANIMAL SCIENCE (AN SC)

422. Quantitative Inheritance and Animal Breeding (3)
455. Animal Genetics (2)

APPLIED MATHEMATICS (A M)

405. (Math. 405) Fourier Series and Partial Differential Equations (3)
417. (Math. 417) Tensor Analysis (3)
418. (Math. 418, Stat. 418) Discrete Probability Theory (3)
419. (Phys. 419) Theoretical Mechanics (3)
431. (Math. 431) Ordinary Differential Equations (3)
441. (Math. 441) Matrix Algebra (3)
451. Functions of Several Variables (3)
452. (Math. 452) Functions of a Complex Variable (3)
461. (Phys. 461) Theoretical Mechanics (3)
490. Special Topics (1-12)

510-511. Linear Methods (3 each) Matrices, quadratic forms, ordinary and partial differential equations, integral equations, transforms, Fourier series. Prerequisite or concurrent: A.M. 452.

512-513. (Stat. 512-513) Introduction to Stochastic Processes (3) Markov chains, random walk and recurrent events, queuing theory, time-dependent stochastic processes.

520. Asymptotic Techniques in Differential Equations (3) Asymptotic series; applications to ordinary and singular perturbation problems. Prerequisite: A.M. 511.

540. Magnetohydrodynamics (3) The mathematical description of the interaction of an electrically conducting fluid with electromagnetic fields. Prerequisites: A.M. 511, Phys. 557.

550. (Phys. 550) Applied Group Theory (3) Representations of discrete and continuous groups, applications to theoretical physics and differential equations, varying emphasis on the specific applications. Prerequisite: A.M. 510.

555. Introduction to Group Representations (3) An introduction to matrices, groups, group representations, characters, and orthogonal functions, with orientation to chemistry and physics.

573. Special Topics (2-12) Various topics according to instructor and students. Prerequisite: second-year graduate standing.

THE ARTS (ARTS)

400. Contemporary Forms in the Arts (3)

BEHAVIORAL SCIENCE (BEHSC)

501. Behavioral Science (4) Integration of bio-psycho-social substrates of behavior, variability in behavior during development, and behavioral correlates with disease and health.

502. Behavioral Science (3) Continued integration of bio-psycho-social substrates with emphasis on adaptation, during development, and behavioral correlates with disease and health.

503. Behavioral Science (3) Continued integration of behavioral substrates with emphasis on personality, emotions, nervous system, stress, behavioral correlates of disease, communication, and society. Prerequisite: Beh.Sc. 502.

511. Medical Statistics and Research Design (2) Use of theoretical and applied statistics in medical research design and in the interpretation of data.

521. Primate Behavior (3) Monkey-to-man survey of intelligence, learning, social behavior, emotions, growth, and physiology; techniques of primate research.

531. Behavioral and Physiological Correlates of Stress (3) Effects of stress on all physiological processes and role of learning, cognition, personality, and culture in adapting to stress.

535. Nervous Systems and Behavior (3) Synthesis on behavioral science, neurobiology, and physiology with emphasis on integrative functions of peripheral, central, and autonomic nervous systems.

537. Mechanisms of Memory (2) Discussion of physiological mechanisms involved in information storage and retrieval. Experimental design in memory research is emphasized.

540. Seminar (1-6) Critical discussion of current literature and research within the behavioral sciences, emphasizing research design, methods, interpretation, and synthesis.

551. Health, Illness, and Culture (3) A medical sociology seminar devoted to the sociocultural aspects of health and sickness.

555. Behavior Change (3) Review of behavioral science research and theory relevant for behavior change procedures used in medicine.

570. Special Topics (1-6) Original and current literature and research methods in special areas in the behavioral sciences.

590. Research Problems (3-12) Independent work to develop and test creative and original hypotheses.

BIOLOGICAL HEALTH (B H)

403. Child Health Needs and Services (3)

BUSINESS EDUCATION (BUSED)

456. Principles and Problems in Business Education (1-3)
459. Improvement of Instruction in Business Skill Subjects (1-3)
460. Curriculums in Business Education (3)
461. Improvement of Instruction in Basic Business Subjects (3)
462. Teaching of Shorthand and Typewriting (3)
463. Teaching of Bookkeeping (3)

575. Administration and Supervision in Business Education (3) Work of administrators, supervisors, and others responsible for improvement of instruction in business education; use of vocational testing; job analysis. Prerequisite: 6 credits in secondary education.

576. Introduction to Research in Business Education (3) Methods of research in business education; opportunity to compile annotated bibliographies on current problems; analysis and evaluation of significant research.

577. Evaluation of Research and Empirical Literature in Business Education (3) Application of evaluation methods to current literature in business education; special attention to research studies. Prerequisite: Bus.Ed. 576.

578. Seminar in Business Education (1-6) Intended for graduate students preparing theses or final documents, or for those working on special studies in business education. Prerequisite: Bus.Ed. 577.

CHINESE (CHNS)

489. Readings in Chinese (1-6)

COMMUNITY DEVELOPMENT (COM D)

401. Socioeconomic Change and the Process of Dislocation (3)
402. Politics, Policy, and Community Action (3)
403. Ideal Communities (3)
404. Interpersonal and Group Processes in Community Change (3)
405. Community Mental Health: An Ecological Approach to Human Services (3)
406. Planning and Evaluating Human Service Programs (3)
407. Community Conflict (4)
417. Identifying Community Power Structures (3)
418. Community Organizing (5)
419. Comparative Community Development (3)

CONSUMER SERVICES AND EQUIPMENT (CS EQ)

403. Lecture-Demonstration Techniques (3)
413. Home Equipment (3)
450. Problems in Household Equipment (1-6)

CONSUMER STUDIES (C S)

416. (I.F.S. 416) Consumer Role of Family (3)
420. Consumer Industries (4)
430. Societal Aspects of Consumer Problems (2)

CULTURAL FOUNDATIONS OF EDUCATION (CF ED)

416. (Soc. 416) Sociology of Education (3)
417. Philosophic Basis of Education (3)
418. History of Education in the United States (2-3)
419. History of Education in Ancient and Medieval Times (3)
420. History of Modern European Education (3)
422. Introduction to Comparative Education (3)
466. Race, Poverty and the Schools (3)

515. Experimentalist Philosophies of Education (2-3) John Dewey's educational philosophy and later formulations by Bode, Kilpatrick, Childs, Brameld, and others. Prerequisite: C.F.Ed. 417 or 6 credits in philosophy.

516. Topical Seminar on School and Society (2-6) An intensive and comprehensive analysis of one selected aspect of the relationship of educational institutions to their societal setting. Prerequisite: C.F.Ed. 416.

517. Existential Philosophy of Education (3) The nature, aim, organization, policy, and process of education examined from the viewpoint of existential philosophy and existential phenomenology. Prerequisite: Cf.Ed. 417 or 6 credits in philosophy at the 400 level or above.

519. Contemporary Philosophies of Education (2-3) Implications for education of various types of Realism, Idealism, Existentialism, and Analytic philosophy. Prerequisite: C.F.Ed. 417 or 6 credits in philosophy.

521. Education in the Latin-American Countries (2-3) Recent educational progress in Central and South America, with special reference to Mexico, Cuba, Puerto Rico, Brazil, Chile, and Argentina. Prerequisite: C.F.Ed. 422 or 6 credits in Latin-American studies.

522. Comparative European Education (2-3) Educational policies and practices in school systems in western and central European nations. Prerequisite: C.F.Ed. 422.

524. Education in Communist Countries (2-3) Educational policies and practices in Soviet Russia and other Communist countries. Prerequisite: C.F.Ed. 422 or 6 credits in Russian or Asian studies.

526. Education in Developing Countries (2-3) Educational problems and trends in selected countries, with particular reference to Africa, the Middle East, and Southeast Asia. Prerequisite: C.F.Ed. 422 or 6 credits in Asian, African, or Latin-American studies.

528. Education in Canada (2-3) Development and organization of education in the Canadian provinces; emphasis on dual systems of Ontario and Quebec. Prerequisite: C.F.Ed. 422.

532. Social Change, Cultural Dynamics, and Education (2-3) The social role of the school in a rapidly changing society. Prerequisite: C.F.Ed. 416.

534. Readings in Philosophy of Education (1-6) Selected philosophic writings—classic, modern, or contemporary—on education. Prerequisite: C.F.Ed. 417 or 6 credits in philosophy.

536. Educational Leaders and Classics (2-3) Selected leaders and their writings, with emphasis on historical-social context, including Quintilian, Erasmus, Comenius, Fénelon, Pestalozzi, and Mann.

592. Seminar in Cultural Foundations of Education (1-9) Conferences and discussions designed to meet the need for special study of particular areas in cultural foundations of education. Prerequisites: 12 credits of graduate work in cultural foundations of education.

ENGINEERING (ENGR)

410. Technology—Its Character, Role and Function (3)
450. Patent Fundamentals (3)

500. Special Topics in Engineering (1-3)

ENGINEERING GRAPHICS (E G)

421. Engineering Graphics for Teachers (3)

ENVIRONMENTAL RESOURCE MANAGEMENT (E R M)

400. Senior Seminar (1)
401. Special Studies (1-4)
410. Pollution of Environmental Systems (3)
411. Legal Aspects of Resource Management (2)
412. Resource Systems Analysis (3)
413. Case Studies in Ecosystem Management (3)

FAMILY AND COMMUNITY MEDICINE (FCMED)

510. Normal Sexual Development (1) The basis, development, and pattern of normal sexual development, with an emphasis on the range of "normal."

515. Economics of Health Care (1) Health costs and various means of meeting them.

527. Community Health Agencies (2) Students individually study community health agencies in depth, sharing experiences in seminars with other participants, agency personnel, and faculty.

GEOLOGICAL SCIENCES (G SC)

412. Geology of the Solar System (3)

HEALTH PLANNING AND ADMINISTRATION (H P A)

410. Principles of Public Health Administration (3)
420. Environmental Health (3-6)
430. Principles of Health Planning (3)
431. Health Planning Methods (3)
432. Health Systems Management (3)
433. Health Systems Theory (3)

HOUSING AND INTERIORS (H I)

410. Textile Design I (3)
411. Textile Design II (3)
412. Textile Design III (3)

HUMAN DEVELOPMENT (H DEV)

400. Special Problems in Human Development (1-6)
401. Professional Issues in Human Development (1-3)
499. Senior Thesis (1-10)

516. Methods of Research in Human Development (1-6) Review of problems and techniques of research in human development.

HUMANITIES (HUMAN)

490. (Sec.Ed. 490) Humanities for Teachers (3)

501. Human Values in Medical Care (2) Analysis of questions, concepts, and ramifications of moral and religious values of health and illness; principles of professional responsibility.

505. Ethics and Human Experimentation (2) An analysis of the ethical, moral, and legal aspects of clinical investigation in medicine.

511. Humanities (2) Selected issues in the history and philosophy of science and their relation to culture.

521. Philosophical Ethics (2) A critical delineation and examination of the conceptual framework of ethics.

525. Philosophy of Science (2) An introduction to the basic concepts of the philosophy of science.

541. Science and American Democracy (2) The development of the sciences and institutions of scientific endeavor from colonial times to the modern era.

570. Special Topics (1-6) Specialized study of selected topics in the humanities.

INSTRUCTIONAL MEDIA (INSTM)

411. Orientation to Instructional Media (2)
412. Production and Utilization of Graphic Stimulus Materials (3)
413. Production of Educational Motion Pictures (3)
414. Television in Education (3)

INTERNATIONAL UNDERSTANDING (INT U)

400. World Affairs and International Understanding (3-6)

ITALIAN (IT)

415. Dante (3)
420. Petrarca and Boccaccio (3)
425. The Literature of the Italian Renaissance (3)
450. Nineteenth-Century Italian Literature (3)

ITALIAN

460. Twentieth-Century Italian Literature (3)
497. Problems in Italian Literature (3-10)

588. Seminar in Italian Literature (3-12) Common and individual research in special problems. *Mr. Triolo*

LABOR STUDIES (L S)

400. Comparative Industrial Relations Systems (3)
411. Trade Union Administration (3)
413. (Econ. 413) Comparative Labor Movements (3)
414. (Econ. 414) Theories of the Labor Movement (3)
415. Labor Movements in Developing Areas (3)
433. (Pl.Sc. 433) The Law of Labor-Management Relations (3)
435. Labor Relations in the Public Sector (3)
454. (Soc. 454) Industry and the Community (3)
455. (Soc. 455) Occupations and Professions (3)
456. (Hist. 456) History of American Labor (3)
457. (Soc. 457) Field Work in Industrial Society (1-6)
489. Problems in Labor Studies (1-9)

LANDSCAPE ARCHITECTURE (LARCH)

420. Landscape Ecology (3)
425-426. Landscape Construction Problems (3 each)
427. Landscape Construction Problems (2)
434. Urban Park and Recreation Areas (3)
454-455. Landscape Design (3 each)
460-461-462. Advanced Landscape Design (4-8 each)
471. Park Systems (2)
472. Planning and Public Policy (3)
473. Recreation Resource Planning (3)
474. Site Engineering Fundamentals (1)

518. Advanced Problems in Landscape Design (2-12) Selected problems for original investigation in the design, construction, and maintenance of landscape architectural projects.

521. Technical Landscape Architectural Practices (2-12) Specific technical and professional problems in landscape architectural planning and practice. Prerequisites: L.Arch. 462, 471.

LAW ENFORCEMENT AND CORRECTIONS (L E C)

401. Probation, Parole, and Pardons (3)
410. Correctional Counseling Processes (3)
430. Correctional Institutions and Services (3)
470. Law of Crimes and Corrections (3)
480. Research Literature on Crime and Corrections (3)

LIBERAL ARTS (L A)

450. Independent Study (1-9)
460. Undergraduate Internship (1-4)
480. Technological Change and Human Values (3)
489. Undergraduate Seminar: Selected Topics (3-9)

LITHUANIAN (LITH)

500. Structure of Lithuanian (3) Analysis of the phonology, morphology, and syntax of Lithuanian; comparative linguistic study of Balto-Slavic and Indo-European. Prerequisite: one graduate course in linguistics.

MATERIALS SCIENCE (MATSC)

401. Materials Science for Teachers I (3)
402. Materials Science for Teachers II (3)
404. Process Measurement and Control (1)
406. Introduction to Biomedical Materials (3)
411. (Min. 411) Instrumental Techniques Applied to Materials and Mineral Science Problems (1-5)
Unit A. X-Ray Diffraction
Unit B. Electron Microscopy
Unit C. Spectroscopy
Unit D. Electron Probe Analysis
Unit E. Scanning Electron Microscopy
412. Quantitative Microstructural and Particulate Characterization (1)
416. Materials Preparation (2)
420. Mathematical Modelling for Materials Scientists (3)
421. (Min. 421) X-Ray Diffraction (3)
431. (Min. 431) Instrumentation for Physical Measurement and Control (3)
490. Special Topics in Materials Science (1-9)

500. Materials Research for Teachers (3) Independent research on a problem from materials science. Topic chosen by consultation with the supervising faculty. Written report required. Prerequisite: Mat.Sc. 402.

512. (Gchem. 512) Principles of Crystal Chemistry (2-4) Relation of structure to ionic size and nature; influence of pressure and temperature on structure; chemical-structural defects, crystalline solutions, phase-transitions.

514. Characterization of Materials (3) Classical and new (microprobe, scanning microscope, magnetic resonance, and Mossbauer) techniques for the characterization of composition, structure, defects, and surfaces.

524. (Gchem. 524) Vibrational Spectra of Materials and Minerals (2) Infrared and Raman spectroscopy of solid materials with applications to crystal chemistry, materials characterization and glass research. Prerequisites: Phys. 412, 471.

531. (Min. 531) Electron Transmission Microscopy in the Materials and Mineral Sciences (3) Discussion of electron image contrast theory as a tool for study of atomic substructures in the materials and mineral sciences.

532. (Min. 532) Structure Analysis (2) Crystal structure determination methods: space groups, structure factors, heavy atoms and isomorphous replacement, Fourier synthesis, Patterson maps, inequalities, refinement techniques. Prerequisite: Mat.Sc. (Min.) 421.

533. (Min. 533) Single Crystal Methods (2) Experimental techniques in crystal structure determination: crystal selection, space group determination, measurement of intensities, analysis of data. Prerequisite: Mat.Sc. (Min.) 421.

534. (Min. 534) Diffraction by Crystals (2) Interaction of radiation with matter: coherent and incoherent scattering, extinction, fluorescent, polarization. Prerequisite: Mat.Sc. (Min.) 421.

535. (Min. 535) Geometrical Crystallography (3) Derivation of lattices, types, point groups and space groups with applications.

538. (Min. 538) Electron Beam Analysis of Solids Via X-Ray and Electron Emission (3) Theory of phenomena occurring in electron-bombarded solids and their applications to analysis of solids.

540. Crystal Anisotropy (2) Symmetry aspects of crystals and physical properties. Matrix and tensor methods. Prerequisite: Phys. 412.

542. Magnetic Methods in Materials Science (3) Static magnetic (susceptibility type) and spectroscopic methods (nuclear and electron magnetic resonance, Mossbauer spectroscopy) for materials characterization and structural analysis. Prerequisite: Phys. 413.

550. Evaporation and Condensation of Solids (2) Thermodynamics of evaporation and condensation of solids; condensation processes including thin films and epitaxial growth and their applications.

552. Theory and Practice of Crystal Growth (3) Theoretical approaches to crystal growth and of the various techniques used in growing crystals.

554. Electronic Spectra of Materials (2) Crystallographic and thermodynamic applications of crystal field theory. Electronic spectra of crystals and glasses. Luminescent spectra and phosphor characterization. Prerequisite: Phys. 471.

564. Structure and Properties of Carbons and Graphite (3) Relation of the ideal and defect structure of polycrystalline carbons and graphite to their mechanical, electronic, thermal, and optical properties. Prerequisite: Phys. 412.

570. Catalytic Materials (3) Preparation and characterization of solid catalytic materials. Relationships between their surface, defect, and electronic properties and catalytic activity. Prerequisite: Chem. 452.

MINERAL ENGINEERING (MIN E)

424. (Metal. 424) Coal Preparation (3)

PATHOLOGY (PATH)

501. Principles of Pathology (4) The fundamentals of reaction to injury at cellular and tissue levels emphasizing the pathogenesis of functional, structural, and biochemical abnormalities. Prerequisite: admission to College of Medicine.

502. Principles of Pathology (4) The fundamentals of human disease with emphasis on pathogenesis of functional, structural, and biochemical abnormalities at the organ system level. Prerequisite: admission to College of Medicine.

510. The Clinical Laboratory in Laboratory Medicine (5) Seminars, tutorials, and independent analysis by the student of specific laboratory problems which relate to human disease. Prerequisites: admission to College of Medicine; Path. 501, 502.

513. Applied Surgical Pathology (4) Student will study tissues daily received by the surgical pathology laboratory. Problems encountered in many clinical specialties will be considered. Prerequisites: admission to College of Medicine; Path. 501, 502.

516. Autopsy Pathology (5) Students will first assist and then perform autopsies under supervision. Emphasis will be on correlations with clinical and experimental medicine. Prerequisites: admission to College of Medicine; Path. 501, 502.

520. Biology of Neoplasia (3) Detailed examination of the initiation and pathogenesis of animal neoplasms with emphasis on the relationship to human neoplasia. Prerequisite: admission to College of Medicine.

524. Biological Membranes, Structure and Function (2) Critical consideration of biological membranes emphasizing comparative structure and biochemical composition through small group discussion and review of current literature. Prerequisite: admission to College of Medicine.

530. Tropical Pathology (4) Study of diseases commonly encountered in tropical areas with emphasis on parasites and infectious and nutritional disorders. Prerequisite: admission to College of Medicine; Path. 501, 502.

540. Development of Educational Tools and Methods in Pathology (3) Development of new educational tools and methods to teach pathogenesis of disease to patients, medical students, and medical technology students. Prerequisite: admission to the College of Medicine.

560. Pathology Seminar (1) Staff and student seminar covers current research and educational and service developments in the field. Prerequisite: admission to College of Medicine.

570. Special Topics in Pathology (1-6) Specialized training in advanced research techniques available in the department. Prerequisite: admission to College of Medicine.

590. Research Problems in Pathology (1-12) Individualized research on pathology problems conducted by students in medical school laboratories. Prerequisite: admission to College of Medicine.

PHYSIOLOGY (PHSIO)

520. Medical Physiology (2) Cellular physiology including membrane permeability; bioelectric potentials, muscle contractions, secretion; cardiovascular physiology including hemodynamics, cardiac function and output, peripheral circulations.

521. Medical Physiology (4) Organ and metabolic physiology, including renal, endocrine, neuromuscular, gastrointestinal, and respiratory.

525. General Physiology (2) Cellular processes of accumulation membrane transport, bioelectric potentials, contraction, and secretion in erythrocytes, nerves. sensory receptors, muscles, glands, excretory organs.

530. Metabolic and Endocrine Physiology (3) Regulations of carbohydrates, fatty acid and protein metabolism; regulation of hormone secretion; effects of hormones on water and cell metabolism.

532. Reproductive Physiology (3) Physiology of male and female reproductive systems, including synthesis, regulation of secretion, and mechanism of action of the steroids and polypeptide hormones involved. Prerequisites: Phsio. 520, 521.

534. Heart and Skeletal Muscle (2) Discussion of structure, chemistry, and physiology of heart and skeletal muscle. Prerequisites: Phsio. 520, 521.

536. Gastrointestinal Physiology (2) Mechanisms of absorption and secretion by stomach, intestine, pancreas, and gallbladder. Neural and hormonal regulation, bioelectric potentials, pathophysiology. Prerequisite: Phsio. 521.

550. Seminar (1 per term) Critical appraisal by staff and students of current research developments and of data collected in current investigations.

PHYSIOLOGY

570. Special Topics (1-6) Training in the use of research techniques; examination in depth of a specialized topic on the level of current research.

590. Research Problems (1-12) Individualized research conducted by students in departmental laboratories.

PLANT SCIENCE (PLTSC)

400. Principles of Plant Science Research (2)
401. Independent Study in Plant Sciences (1-6)

POLISH (POL)

501. Readings in Polish Literature (3-6) Individual reading and research in nineteenth and twentieth century Polish literature and literary criticism.

POLYMER SCIENCE (PLMSC)

406. Introduction to the Materials Science of Polymers (3)
407. Technology and Applications of Polymeric Materials (3)
408. Polymeric Materials Laboratory (1)
409. Introduction to Properties of Polymeric Materials (3)
410. Polymer-Based Composite Materials (3)

560. Properties of Polymeric Materials (3) Macroscopic and microscopic behavior of polymeric materials. Interpretation of properties in terms of structure. Prerequisite: Plm.Sc. 406.

562. Polymeric Materials Characterization Laboratory (2) Characterization of polymeric materials by chemical and physical methods. Prerequisite: Plm.Sc. 406.

POPULATION ISSUES

Qualified students may select Population Issues as an optional area of specialization when majoring either in economics, geography, or sociology. Additional information is given under the description of those majors in the preceding section.

PORTUGUESE (PORT)

588. Seminar in Portuguese and Brazilian Literature (3-12) Common and individual research in special problems. *Mr. Moser*

SAFETY EDUCATION (SAFED)

450. Visual and Other Aids in Safety Education (3)
451. Teaching Traffic Safety and Automobile Operation (3)
452. Organization and Supervision in Safety Education (3)

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Graduate Degree Programs

1973-1974

THE PENNSYLVANIA STATE UNIVERSITY

GRADUATE DEGREE PROGRAMS

GENERAL CATALOG ISSUE

SEPTEMBER 1973

PENN STATE COLLECTION

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GRADUATE CALENDAR*

SUMMER TERM 1973

MAY 1973

21 Monday — Last Date for a Prospective Graduate Student to Submit Completed Application Materials for Admission to the Summer Term 1973

21 Monday — Last Date for a Graduate Student to Apply for Permission to Resume Study in the Summer Term 1973

JUNE

21, 22 Thursday P.M. and Friday — Preexaminations in German for Advanced Degree Candidates

21, 22 Thursday P.M. and Friday — Summer Term Registration

25 Monday — Summer Term Classes Begin 8:00 A.M.

29 Friday — Last Date for an August Graduate to Pay Thesis Fees *and* to Activate Diploma Card in Registrar's Office

30 Saturday — Last Date for an August Graduate to Deliver Doctoral Thesis to Committee

JULY

2 Monday — Last Date for Registering with Foreign Language Departments (other than French and Spanish) for Written Language Examinations

3 Tuesday — Last Date for Registering with Educational Testing Service, Princeton, N.J., for French and Spanish Written Language Examinations**

4 Wednesday — Independence Day Holiday

7 Saturday — Last Date for Final Oral Doctoral Examinations for August Graduates

7 Saturday — Last Date for an August Graduate to Deliver Master's Thesis or Paper to Adviser

17 Tuesday — Last Date for Written Foreign Language Examinations (other than French and Spanish) for Advanced Degree Candidates

23 Monday — Last Date for an August Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Completion of Required Papers

23 Monday — Last Date for an August Graduate to Order Cap, Gown, and Hood Locally

28 Saturday — Written French and Spanish Language Examinations for Advanced Degree Candidates +

AUGUST

11 Saturday A.M. — Last Date for Submitting a Petition to Graduate Dean to Graduate in Absentia in August

18 Saturday — Eight-Week Summer Term Classes End 12:25 P.M.

26 Sunday — Commencement

---

*This calendar was approved on October 2, 1972, and is subject to change without notice. In preparing the calendar for an academic year, the University makes every effort to avoid conflicts with religious holidays. However, such conflicts are sometimes unavoidable. When they occur, efforts are made to make special arrangements for the students affected.

**ETS registration fee ($10) must accompany Registration Form, available from 205 Kern Graduate Building. A late registration fee of $3.50 for registrations received one week later.

+Tests administered by The Pennsylvania State University. Contact Professor A. V. Kozak, 166 Chambers Building.

FALL TERM 1973

AUGUST

6 Monday — Last Date for a Prospective Graduate Student to Submit Completed Application Materials for Admission to the Fall Term 1973

6 Monday — Last Date for a Graduate Student to Apply for Permission to Resume Study in the Fall Term 1973

SEPTEMBER

5-7 Wednesday to Friday — Preexamination in German for Advanced Degree Candidates

5-7 Wednesday to Friday — Fall Term Registration

10 Monday — Fall Term Classes Begin 8:00 A.M.

14 Friday — Last Date for Registering with Foreign Language Departments (other than French and Spanish) for Written Language Examinations

27 Thursday — Last Date for a December Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office

27 Thursday — Last Date for Registering with Educational Testing Service, Princeton, N.J., for French and Spanish Written Language Examinations*

OCTOBER

2 Tuesday — Last Date for Written Foreign Language Examinations (other than French and Spanish) for Advanced Degree Candidates

6 Saturday — Last Date for a December Graduate to Deliver Doctoral Thesis to Committee

13 Saturday — Last Date for Final Oral Doctoral Examination for December Graduates

13 Saturday — Last Date for a December Graduate to Deliver Master's Thesis or Paper to Adviser

27 Saturday — Written French and Spanish Language Examinations for Advanced Degree Candidates**

29 Monday — Last Date for a December Graduate to Deliver Thesis to the Graduate School Office

29 Monday — Last Date for Departments to Certify Completion of Required Papers for December Graduates

29 Monday — Last Date for a December Graduate to Order Cap, Gown, and Hood Locally

NOVEMBER

17 Saturday A.M. — Last Date for Submitting a Petition to Graduate Dean to Graduate in Absentia in December

17 Saturday — Fall Term Classes End 12:25 P.M.

19-21 Monday to Wednesday — Final Examinations

DECEMBER

1 Saturday — Commencement

---

*ETS registration fee ($10) must accompany Registration Form, available from 205 Kern Graduate Building. A late registration fee of $3.50 for registrations received one week later.

**Tests administered by The Pennsylvania State University. Contact Professor A. V. Kozak, 166 Chambers Building.

WINTER TERM 1974

NOVEMBER 1973

5 Monday — Last Date for a Prospective Graduate Student to Submit Completed Application Materials for Admission to the Winter Term 1974

5 Monday — Last Date for a Graduate Student to Apply for Permission to Resume Study in the Winter Term 1974

DECEMBER

4, 5 Tuesday, Wednesday — Preexamination in German for Advanced Degree Candidates

4, 5 Tuesday, Wednesday — Winter Term Registration

6 Thursday — Winter Term Classes Begin 8:00 A.M.

14 Friday — Last Date for Registering with Foreign Language Departments (other than French and Spanish) for Written Language Examinations

17 Monday — Last Date for a March Graduate to Pay Thesis Fees at Bursar's Office *and* to Activate Diploma Card in Registrar's Office

19 Wednesday — Last Date for Registering with Educational Testing Service, Princeton, N.J., for French and Spanish Written Language Examinations*

19 Wednesday — Winter Term Recess Begins 9:55 P.M.

JANUARY 1974

2 Wednesday — Winter Term Recess Ends

3 Thursday — Winter Term Classes Resume 8:00 A.M.

8 Tuesday — Last Date for Written Foreign Language Examinations (other than French and Spanish) for Advanced Degree Candidates

12 Saturday — Last Date for a March Graduate to Deliver Doctoral Thesis to Committee

19 Saturday — Written French and Spanish Language Examinations for Advanced Degree Candidates (afternoon)**

19 Saturday — Last Date for Final Oral Doctoral Examinations for March Graduates

19 Saturday — Last Date for a March Graduate to Deliver Master's Thesis or Paper to Adviser

FEBRUARY

4 Monday — Last Date for a March Graduate to Deliver Thesis to Graduate School Office

4 Monday — Last Date for Departments to Certify to Graduate School Completion of Required Papers for March Graduates

4 Monday — Last Date for a March Graduate to Order Cap, Gown, and Hood Locally

23 Saturday — Last Date for Submitting a Petition to the Graduate Dean to Graduate in Absentia in March

27 Wednesday — Winter Term Classes End 9:55 P.M.

28 Thursday — Final Examinations

MARCH

1, 2 Friday, Saturday — Final Examinations Continue

9 Saturday — Commencement

---

*ETS registration fee ($10) must accompany Registration Form, available from 205 Kern Graduate Building. A late registration fee of $3.50 will be charged for registrations received one week late.

**Tests administered by The Pennsylvania State University. Contact Professor A. V. Kozak, 166 Chambers Building.

SPRING TERM 1974

FEBRUARY 1974

12 Tuesday — Last Date for a Prospective Graduate Student to Submit Completed Application Materials for Admission to the Spring Term 1974

12 Tuesday — Last Date for a Graduate Student to Apply for Permission to Resume Study in the Spring Term 1974

MARCH

12, 13 Tuesday, Wednesday — Preexamination in German for Advanced Degree Candidates

12, 13 Tuesday, Wednesday — Spring Term Registration

14 Thursday — Spring Term Classes Begin 8:00 A.M.

22 Friday — Last Date for Registering with Foreign Language Departments (other than French and Spanish) for Written Language Examinations

27 Wednesday — Last Date for a June Graduate to Pay Thesis Fees at Bursar's Office *and* to Activate Diploma Card in Registrar's Office

27 Wednesday — Last Date for Registering with Educational Testing Service, Princeton, N.J., for French and Spanish Written Language Examinations*

APRIL

6 Saturday — Last Date for a June Graduate to Deliver Doctoral Thesis to Committee

9 Tuesday — Last Date for Written Foreign Language Examinations (other than French and Spanish) for Advanced Degree Candidates

13 Saturday — Last Date for Final Oral Doctoral Examinations for June Graduates

13 Saturday — Last Date for a June Graduate to Deliver Master's Thesis or Paper to Adviser

27 Saturday — Written French and Spanish Language Examinations for Advanced Degree Candidates (afternoon)**

29 Monday — Last Date for a June Graduate to Deliver Thesis to Graduate School Office

29 Monday — Last Date for Departments to Certify to Graduate School Completion of Required Papers for June Graduates

29 Monday — Last Date for a June Graduate to Order Cap, Gown, and Hood Locally

MAY

7 Tuesday — Annual Graduate Faculty Meeting

18 Saturday — Last Date for Submitting a Petition to the Graduate Dean to Graduate in Absentia in June

22 Wednesday — Spring Term Classes End 12:25 P.M.

23-25 Thursday to Saturday — Final Examinations

27 Monday — Memorial Day

JUNE

1 Saturday — Commencement

---

*ETS registration fee ($10) must accompany Registration Form, available from 205 Kern Graduate Building. A late registration fee of $3.50 will be charged for registrations received one week late.

**Tests administered by The Pennsylvania State University. Contact Professor A. V. Kozak, 166 Chambers Building.

SUMMER 1974

MAY 1974

13 Monday — Last Date for a Prospective Graduate Student to Submit Completed Application Materials for Admission to the Summer Term 1974

13 Monday — Last Date for a Graduate Student to Apply for Permission to Resume Study in the Summer Term 1974

15 Wednesday — Last Date for Registering with Educational Testing Service, Princeton, N.J., for French and Spanish Written Language Examinations*

JUNE

11 Tuesday — Preexamination in German for Advanced Degree Candidates

11 Tuesday — Summer Term Registration

12 Wednesday — Summer Term Classes Begin 8:00 A.M.

15 Saturday — Written French and Spanish Language Examinations for Advanced Degree Candidates (afternoon)**

21 Friday — Last Date for Registering with Foreign Language Departments (other than French and Spanish) for Written Language Examinations

26 Wednesday — Last Date for an August Graduate to Pay Thesis Fees at Bursar's Office *and* to Activate Diploma Card in Registrar's Office

JULY

4 Thursday — Independence Day Holiday

6 Saturday — Last Date for an August Graduate to Deliver Doctoral Thesis to Committee

9 Tuesday — Last Date for Written Foreign Language Examinations (other than French and Spanish) for Advanced Degree Candidates

13 Saturday — Last Date for Final Oral Doctoral Examinations for August Graduates

13 Saturday — Last Date for an August Graduate to Deliver Master's Thesis or Paper to Adviser

29 Monday — Last Date for an August Graduate to Deliver Thesis to Graduate School Office

29 Monday — Last Date for Departments to Certify to Graduate School Completion of Required Papers for August Graduates

29 Monday — Last Date for an August Graduate to Order Cap, Gown, and Hood Locally

AUGUST

17 Saturday — Last Date for Submitting a Petition to the Graduate Dean to Graduate in Absentia in August

21 Wednesday — Summer Term Classes End 9:55 P.M.

22-24 Thursday to Saturday — Final Examinations

31 Saturday — Commencement

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*ETS registration fee ($10) must accompany Registration Form, available from 205 Kern Graduate Building. A late registration fee of $3.50 will be charged for registrations received one week late.

**Tests administered by The Pennsylvania State University. Contact Professor A. V. Kozak, 166 Chambers Building.

FALL 1974

AUGUST 1974

5 Monday — Last Date for a Prospective Graduate Student to Submit Completed Application Materials for Admission to the Fall Term 1974

5 Monday — Last Date for a Graduate Student to Apply for Permission to Resume Study in the Fall Term 1974

SEPTEMBER

4-6 Wednesday to Friday — Preexamination in German for Advanced Degree Candidates

4-6 Wednesday to Friday — Fall Term Registration

9 Monday — Fall Term Classes Begin 8:00 A.M.

13 Friday — Last Date for Registering with Foreign Language Departments (other than French and Spanish) for Written Language Examinations

23 Monday — Last Date for November Graduate to Pay Thesis Fees at Bursar's Office *and* to Activate Diploma Card in Registrar's Office

26 Thursday — Last Date for Registering with Educational Testing Service, Princeton, N.J., for French and Spanish Written Language Examinations*

OCTOBER

1 Tuesday — Last Date for Written Foreign Language Examinations (other than French and Spanish) for Advanced Degree Candidates

5 Saturday — Last Date for a November Graduate to Deliver Doctoral Thesis to Committee

12 Saturday — Last Date for Final Oral Doctoral Examinations for November Graduates

12 Saturday — Last Date for a November Graduate to Deliver Master's Thesis or Paper to Adviser

26 Saturday — Written French and Spanish Language Examinations for Advanced Degree Candidates (afternoon)**

28 Monday — Last Date for a November Graduate to Deliver Thesis to Graduate School Office

28 Monday — Last Date for Departments to Certify to Graduate School Completion of Required Papers for November Graduates

28 Monday — Last Date for a November Graduate to Order Cap, Gown, and Hood Locally

NOVEMBER

16 Saturday — Last Date for Submitting a Petition to the Graduate Dean to Graduate in Absentia in November

16 Saturday — Fall Term Classes End 12:25 P.M.

18-20 Monday to Wednesday — Final Examinations

30 Saturday — Commencement

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GENERAL INFORMATION

THE GRADUATE SCHOOL

Graduate work at The Pennsylvania State University was first offered in 1862, but for some time there were few graduate students and graduate instruction was relatively unorganized. A committee of the General Faculty eventually was given the responsibility of establishing standards and regulations governing graduate work and the granting of master's and certain technical degrees. The Graduate School was formally established in 1922 by the President and the Board of Trustees. An administrative staff was organized, and the Graduate Faculty was formed. The University Senate delegated to this faculty responsibility for graduate affairs, subject to review. In 1924 the Board of Trustees authorized the granting of the degree of Doctor of Philosophy. On May 9, 1971 a Graduate Council was established for the Graduate School. Today graduate study is offered in 125 major programs, with 15 advanced academic and professional degrees being conferred. During the academic year 1972-1973, 5,500 to 6,100 graduate students were enrolled each term, and 1,957 advanced degrees were conferred, of which 424 were doctorates.

The Graduate School maintains close contact with other graduate schools in order to keep abreast of developments in graduate education throughout the country. It is a member of the Association of Graduate Schools (an organization within the Association of American Universities) and of the Council of Graduate Schools in the United States.

MAJOR ROLE

The major role of the Graduate School is to emphasize those aspects of University activity which pertain directly to major programs in graduate study. Through its Graduate Faculty it represents a large segment of the academic strength of the University and is thus a dominant force in sustaining and furthering the intellectual quality of the entire institution. The eleven colleges formulate study and research programs appropriate to their fields. The Graduate Faculty consists of those members of the college faculties who have authorization through the Graduate School to offer courses and seminars and supervise research and theses consistent with the highest academic standards. Thus the Graduate School may be regarded as a federation of selected segments of the college faculties.

GOVERNANCE

The governance of the Graduate School is vested in a Graduate Council, whose legislative authority is subject to the specific restrictions of the "Articles of Authority." The Council forms its own committee structure under bylaws outlined in "Standing Rules of the University Graduate Council." A summary of actions taken by the Council is published in the *Senate Record.*

Executive and administrative matters of the Graduate School are the responsibility of the Dean, who is charged directly with enforcement of the regulations of the Graduate School and with organization of its administrative procedures. The Dean has a major responsibility to enhance and insure the high quality of graduate study and research of graduate students on the University Park Campus and at other locations where such graduate work is conducted. He exercises leadership in initiating new programs and in restructuring or phasing out marginal and obsolete ones. The Dean encourages and assists in the development of multidisciplinary programs. He is assisted in this work by an administrative and clerical staff.

ADMINISTRATIVE DIVISIONS

There are four major administrative divisions in the Graduate School to which the students may go directly for answers to the questions which require administrative assistance or decisions:

1. *Graduate Admissions,* 310 Kern Graduate Building. The Office of Graduate Admissions has responsibility for processing all matters pertaining to a student's admission.
2. *Graduate Student Programs,* 211 Kern Graduate Building. The functions of the Office of Graduate Student Programs encompass responsibilities for the academic involvement and concerns of all graduate students from the time they are admitted until they graduate, such as: (a) registration of students, (b) readmission of students, (c) maintenance of records, (d) appointment of graduate committees for doctoral students, (e) scheduling of graduate student comprehensive examinations, (f) checking for accomplishment by students of Graduate Faculty requirements for all advanced degrees and preparation of official commencement lists, and (g) attention to student academic problems.
3. *Graduate Fellowships,* 317 Kern Graduate Building. The Office of Graduate Fellowships serves as a clearinghouse for information on available fellowships and other awards for graduate students, administers fellowships and other award programs involving students in more than one college, and seeks support for graduate students attending the University.
4. *Theses and Publications,* 320 Kern Graduate Building. The Office of Theses and Publications is responsible for reviewing all theses to meet Graduate School specific format requirements consistent with the attainment of high scholarly standards. The office prepares, arranges for publication, and provides source materials through the major Graduate School publications.

PROGRAMS AT OTHER LOCATIONS

Behrend Graduate Center — The Behrend Graduate Center at Erie opened with the winter term, January 1969, and provides convenient opportunity for graduate education to persons residing in northwestern Pennsylvania. It has been established to offer individual courses and a program leading to the degree of Master of Engineering with a major in engineering science.

King of Prussia Graduate Center — The King of Prussia Graduate Center near Philadelphia opened in 1963. Its programs lead to the degrees of Master of Engineering with majors in engineering science and industrial engineering, and Master of Education with a major in mathematics.

The Capitol Campus — The Capitol Campus, located near Middletown and named for its proximity to the State capitol, was opened in 1966. Graduate programs leading to the degrees of Master of Administration, Master of Arts with majors in American studies and in humanities, Master of Education with a major in elementary education, Master of Engineering with a major in engineering science, Master of Public Administration, and Master of Regional Planning are currently offered.

The Milton S. Hershey Medical Center — The University's Medical Center was established in 1963, and the first class of medical students entered in the fall of 1967. The Center is located in Hershey, Pennsylvania, twelve miles from Harrisburg. In conjunction with The Pennsylvania State University's Graduate School, the College of Medicine offers programs leading to the Master of Science degree with a major in laboratory animal medicine, and to the Doctor of Philosophy and Master of Science degrees with majors in anatomy, biological chemistry, genetics, microbiology, pharmacology, and physiology.

COOPERATIVE ARRANGEMENTS WITH OTHER INSTITUTIONS

A working arrangement has been established with Jefferson Medical College of Philadelphia whereby a candidate for an advanced degree at Jefferson may do part of his graduate work at The Pennsylvania State University by scheduling relevant courses and research at University

Park. Similarly, a graduate student with an appropriate major at The Pennsylvania State University may earn credits at Jefferson which, with advance approval by his major department or program, will be accepted in partial fulfillment of degree requirements at The Pennsylvania State University.

KERN GRADUATE BUILDING

The new graduate building opened in February and was officially dedicated on March 16, 1971. It has since been officially named the Kern Graduate Building in honor of Dean Emeritus Frank D. Kern, who was the first Dean of the Graduate School. The Graduate School administrative offices are housed on the second and third floors of the building.

GRADUATE COMMONS

The Graduate Commons is located on the first floor of the Kern Graduate Building and provides facilities for the entire Graduate School community and a common meeting ground for faculty and students. The assembly room and multipurpose rooms are used for large group meetings; the smaller rooms are used for seminars and doctoral oral examinations.

Food service is provided in the cafeteria. The lobby is available for display of art work done by students and faculty. Exhibits are normally displayed for two weeks.

The Office of the Graduate Commons Manager serves as a clearinghouse for the scheduling of events planned by organizations and individuals.

GRADUATE STUDENT ASSOCIATION

The Graduate Student Association was established in 1951 as the official voice of graduate students, all of whom are automatically members. It is the particular function of the organization to give to the individual member the opportunity to stimulate student intellectual interests and to bring to light problems and resolve them through discussion and collective action. It provides the occasion for relaxation through its social program. The University allocates an appropriation to the Association to help defray expenses.

The Association has an Executive Board and Council of Representatives, which consists of elected representatives from every graduate department, with voting rights proportionate to the number of students in any given department, nonvoting *ex officio* representatives from graduate living units, and representatives to committees outside the Graduate Student Association. The council meets regularly to conduct the business of the Association; the Executive Board has interim powers to conduct business not requiring the specific action of the Council of Representatives. The executive officers from the board act as official liaison between the council and the Dean of the Graduate School.

The Association has an office in 305 Kern Graduate Building, where it maintains its records and conducts its business. The Graduate Student Association has established the following standing committees: (1) Housing Committee, (2) Program Committee, (3) Academic Affairs Committee, (4) Rules Committee, (5) Committee on Graduate Intramural Athletics, (6) Publications Committee, (7) Student Services Committee, (8) Women's Concerns Committee, and (9) Married Students' Concerns. In addition, the council may institute *ad hoc* committees or presidential commissions at will.

The Association elects six graduate students to serve as full voting members on the University Faculty Senate, five graduate students as voting members to serve on the Graduate Council, and one to serve on the University Council. Membership on the Graduate Council is for a period of one year. Graduate students are eligible to serve on all committees of the Council.

The Association maintains communications among its members through the campus daily newspaper, its own newsletter, scheduled meetings and workshops, and informal use of the Graduate Commons.

FACILITIES

UNIVERSITY LIBRARIES

The libraries at University Park include central collections in the Fred Lewis Pattee Library; three separate branch libraries, serving the Colleges of Earth and Mineral Sciences, Engineering, and Science; and two reading rooms for the Departments of Architecture and Mathematics. They contain approximately 1,300,000 catalogued volumes, some 700,000 government documents, and more than 1,000,000 other bibliographical items (microforms, maps, manuscripts, audio tapes, etc.).

The new Pattee East unit opened in the winter term 1973. It includes five floors on which the Arts, Agricultural, Biological and Health Sciences, Literature and Language, General Reference, and Microforms collections are respectively housed. The new photoduplication section is located on the ground floor.

The central collection includes reference materials in the humanities and social sciences, books, periodicals, newspapers, and microforms in the fields of agriculture, biology, education and psychology, economics and business, the fine arts and humanities, and the natural and social sciences. The branch libraries and reading rooms contain books and journals needed for the subjects studied in those colleges and departments. A number of instructional guides to assist faculty and students in using the facilities are issued by the libraries and may be obtained at service desks. Included among the special resource guides issued by the library are *Newspapers in Microform* and Pennsylvania maps and atlases.

COMPUTATION CENTER

The Computation Center aids in the education and research programs of all academic departments. Its facilities are open to graduate students and faculty engaged in research and to students doing class assignments. Its equipment includes two large IBM computers, an ADAGE AGT-30, a 1401, and several small peripheral machines. The System/370 Model 165 has two and one-half million bytes of fast core storage, 800 million bytes of disk and drum storage, and a large configuration of input/output equipment. Access to the Model 165 can be obtained through high-speed batch terminals located on the main campus or through medium-speed batch terminals located at the Commonwealth Campuses. The System/360 Model 50 is about one-half the size of the Model 165 and is devoted to time-sharing services. Several access stations, providing instant turnaround for short jobs, are available for students first learning to use a computer. Typewriter terminals may access to either the Model 50 APL/360 time-sharing system or the Model 165 remote job entry facility using the dial telephone network. A well-equipped ADAGE AGT-30 Computer Graphics System allows extensive graphics work. An interface to the Model 165 further extends its graphics capability.

The Computation Center staff conducts workshops to acquaint graduate students and faculty with its services. A student who will need the Center's facilities should attend these workshops and should consult the staff early in his research so that a program can be worked out for his project and his work scheduled without delay. Programming consultants in the Center provide advice and assistance in using library programs prepared by the Center and in programming and checking out new applications. The facilities of the Computation Center are widely used for instruction and research in most academic departments at no charge to the student. The Graduate Centers, the Capitol Campus, The Milton S. Hershey Medical Center, the Behrend College, and most of the Commonwealth Campuses have remote batch terminals which permit processing of computer jobs at the central computer equipment operated by the Computation Center at University Park.

OTHER FACILITIES

The University offers many additional facilities which are available to students through their major programs of study.

LIVING ACCOMMODATIONS

Eastview Terrace and Graduate Circle, both located on the eastern side of the campus, provide one-and two-bedroom apartments for married graduate students.

The Eastview Terrace apartments are fire resistant, one-story, steel framework buildings consisting of forty-six one-bedroom units and thirty-two two-bedroom units. The units are unfurnished except for electric stove and refrigerator. For each two units there is a utility room with two stationary laundry tubs and storage space.

Graduate Circle has 144 one-bedroom and 72 two-bedroom apartments in sixteen two-story buildings of brick and frame construction. Each kitchen has a double stainless steel sink with disposal unit, a gas stove, kitchen cabinets, and an electric refrigerator; each bedroom has a built-in chest of drawers. Otherwise the units are unfurnished. There are no facilities for private washing machines in the apartment; however, coin-operated laundries at nominal fees are provided in five of the buildings throughout the area. A storage locker is also provided for each apartment at the laundry location.

Families with children of school age, or with children who will become of school age during the term of the lease, cannot be considered for occupancy in Eastview Terrace and Graduate Circle. The one-bedroom apartments are designed for a husband and wife and the two-bedroom units for a family with not more than two children. An agreement form for graduate housing may be obtained by submitting the "Request for Graduate Housing" card. This request card is to be mailed to the Assignment Office for Campus Residences, 101 Shields Building, University Park, Pa. 16802. Telephone: Area Code 814, 865-7501.

Atherton Hall, located near the Hetzel Union Building, and McKee Hall, located near the Graduate Center, are reserved exclusively for single graduate men and women, providing residence hall room accommodations without food service. Double, single, single occupancy of double rooms, or single room with bath are available.

Other living accommodations available in the community may be located through the Chamber of Commerce, 129 West Beaver Avenue, State College, Pa. 16801; Telephone: Area Code 814, 237-7644.

Graduate students should arrange for their accommodations well in advance of the beginning of classes because it may be very difficult to find convenient housing at the last minute. STUDENTS MUST BE ADMITTED TO THE GRADUATE SCHOOL BEFORE THEIR REQUESTS FOR ON-CAMPUS LIVING ACCOMMODATIONS CAN BE PROCESSED.

STUDENT SERVICES

The facilities and services outlined in the following paragraphs are available to graduate students and, in cases of emergency, to the graduate student's spouse and dependents.

UNIVERSITY HEALTH SERVICES

Located in the central campus area, the Ritenour Health Center is the core of the health service activities and is composed of a dispensary and a hospital. Its facilities are available to full-time graduate students, that is, students registered for 8 or more credits or the equivalent (students holding quarter-time assistantships scheduling 7 to 9 credits, or students holding half-time assistantships scheduling 5 to 7 credits). The outpatient dispensary handles student medical problems from 8:00 a.m. to 11:45 a.m. and from 1:30 p.m. until 4:45 p.m. daily except Saturdays, when hours are from 8:00 a.m. to 11:45 a.m. During other periods, including Sundays and holidays, patients are seen for emergencies only in the Emergency Room of the University Hospital, which is part of the Health Center complex.

The University Hospital is well equipped to handle the more serious illnesses and injuries on an inpatient basis. A fifty-bed facility, it is staffed with professional personnel twenty-four hours a day during the school terms. Should the need arise for special medical or surgical treatment—major surgery, for example—the student is transferred to a hospital facility of his choice.

Included in the Health Center facilities are a dental office for emergency dental care, a physiotherapy department, and a pharmacy which has been enlarged and placed in back of the Health Center in order to expand the outpatient clinic.

Hospitalized students will be charged $10 per day during confinement, and a nominal charge will be made for all drugs dispensed to hospital or dispensary patients. A standard laboratory and X-ray fee is charged for examinations done in the Health Center when ordered by physicians other than the members of the Health Center staff. Consultation with or treatment by physicians other than the professional staff at the Health Center is at the student's expense.

The Ritenour Health Center maintains an ambulance service for local transportation of students with nonambulatory illnesses and injuries.

HEALTH INSURANCE PLAN

The University has arranged for a voluntary group Student Accident and Sickness Insurance Plan with a variety of benefits available to graduate students and their dependents, provided the student is eligible for the services of the Ritenour Health Center and pays the cost of the policy and the appropriate premium for the inclusion of dependents.

The plan is set up on a school year basis beginning with the fall term. At this time a representative of the insurance company maintains an enrollment desk in the Hetzel Union Building. An open enrollment is also held near the beginning of the spring term for coverage until the fall term.

Included in the plan is coverage for accidental death or accident medical benefits, hospitalization, laboratory fees, surgery, and doctors' visits up to fixed amounts, plus major medical expense benefits after satisfaction of $100 deductible for each illness. This plan also provides a major medical expense benefit only, but requires the insured to pay the first $500 as a result of sickness or accident.

Full details are available each year through the representative at Hetzel Union Building or through the local representative (telephone area code 814, 238-6725).

MEDICAID BENEFITS

Graduate students can qualify for most of the benefits that apply to hospitalization and medical treatment under Medicaid. State medical assistance is available upon application to the Office of the Centre County Board of Assistance, Bellefonte, Pa. 16823.

HEALTH SERVICES FOR CHILDREN

Many medical services are available for children under 21 through the State Health Center. The services range from simple immunizations to complicated surgery. Diagnostic study and consultation at the Center are made regardless of the ability to pay. Children may be referred to the Center by physicians or health and welfare agencies. Since many of the services require continual consultation with the physician, referrals must be by physicians located in Centre County. For additional information, consult your doctor, or contact the Health Center at 110 South School Street, Bellefonte, Pa. 16823.

INSURANCE PROTECTION WHILE ATTENDING THE UNIVERSITY

The Pennsylvania State University is an instrumentality of the Commonwealth performing its function of education. It is not liable for the negligence of its officers, servants, and employees when in the exercise of public or governmental powers or in the performance of public or governmental duties incident to the general education work of the University.

Therefore any student who desires insurance protection while in attendance at the University against personal injury and/or against loss of property by fire or theft should arrange personally for whatever insurance seems advisable.

CAREER DEVELOPMENT AND PLACEMENT CENTER

The center functions as both a counseling and placement service for students and as a college. Its primary purpose is to serve students, both individually and in groups, by assisting them through career and educational counseling in formulating and implementing immediate and long-range career plans.

The center cooperates with the colleges and departments of the University to assist students in implementing career plans upon graduation. Services include: (1) a library containing information on career opportunities, employer characteristics, and graduate and professional schools; (2) scheduled interviews with prospective employers who are visiting the campus; (3) a file of employment opportunities for which a student may apply by mail; (4) a listing of career-related summer jobs and internships; (5) workshops in interviewing skills and techniques; and (6) a variety of informational meetings and publications.

TUITION AND CHARGES

The University reserves the right to revise the schedule of tuition and charges without further notice.

TOTAL TUITION FOR EACH TERM

University Park Campus and Medical Center (Nonmedical Students) — 8 or more credits, total charge of $300 for Pennsylvanians and $700 for non-Pennsylvanians; 7 or fewer credits, $37 per credit for Pennsylvanians and $88 for non-Pennsylvanians. (Medical Students) — 8 or more credits, total charge of $435 for Pennsylvanians and $870 for non-Pennsylvanians; 7 or fewer credits, $54 per credit for Pennsylvanians and $108 for non-Pennsylvanians. These rates apply also to off-campus research and other approved individual study.

Graduate Centers and Capitol Campus — 8 or more credits, total charge of $295 for Pennsylvanians and $700 for non-Pennsylvanians; 7 or fewer credits, $33 per credit for Pennsylvanians and $88 for non-Pennsylvanians.

Continuing Education Centers — University Park, $37 per credit for Pennsylvanians and $88 per credit for non-Pennsylvanians; Graduate Centers and Capitol Campus, $33 per credit for Pennsylvanians and $88 per credit for non-Pennsylvanians.

Vocational Education Program — 8 or more credits, total charge of $300 for Pennsylvanians and $700 for non-Pennsylvanians; 7 or fewer credits, $37 per total program for all students (vocational education courses are indicated by "v" following the course number).

Tuition is the same for courses whether audited or taken for credit.

Any student who does not fulfill payment obligations promptly may be charged a late payment fee of $25. A student whose account is delinquent for more than ten days is subject to suspension from the University.

Whenever it appears that an applicant for admission is not domiciled in Pennsylvania, it is assumed that he is a non-Pennsylvanian. If the student who is thus admitted believes that his circumstances do not justify his classification as a non-Pennsylvanian, he may petition the Graduate Dean's office for reclassification. (See Student Resident Status, page 60.)

TUITION REFUND POLICY

Charges for tuition are refundable upon withdrawal from the University only in the event the student obtains an Official Withdrawal Form at the office of the Dean of the Graduate School and presents it, together with his current Certificate of Registration, at the office of the Fee Assessor no later than one calendar month after the effective date of withdrawal from classes. Students who meet these conditions are entitled to receive refunds of charges for tuition for the term in accordance with the following schedule:

Refund of 80 percent upon withdrawal before the end of the first week of the term (sev-

enth consecutive calendar day from the first day of classes) and a decrease of 20 percent for each week thereafter up to and including the fourth consecutive calendar week. No amount will be refunded for withdrawal after the fourth consecutive calendar week of the term.

The University will not release any refund of tuition until at least three weeks have elapsed from the date the payment was received. All refunds will be made by check and mailed to the student's home address.

SPECIFIC CHARGES

In addition to the foregoing tuition and charges, the following charges apply under special conditions and are to be paid independently:

Application fee	$ 15.00
Change of schedule, each change	2.00
Duplicate meal ticket	1.00
Duplicate student identification and activity card	each 4.00
French reading examination	6.00
Music, individual lessons	30.00 to 100.00
Privilege of late payment	25.00
Privilege of late registration	10.00
Dissertation fee for Ph.D. candidates (601)	100.00
Dissertation fee for Ph.D. candidates (611)	100.00
Student parking fee, each term	10.00
Teacher placement service registration fee	5.00
Teacher placement service reactivation fee	5.00
Thesis microfilming and binding fee for master's candidate	10.50
Thesis microfilming and bind fee for doctoral candidate	45.50
Transcript of records (with seal), each copy	1.00
Mailing diploma in absentia	5.00

MOTOR VEHICLE CHARGES

Each graduate student who possesses, maintains, or operates a motor vehicle (including a motorcycle, motor bike, motor scooter, or any other motor-driven vehicle) while at the University is required to register such vehicle with the Traffic Violations Officer during the registration period of each term. There is no registration charge for students who do not desire campus driving or parking privileges. Failure to register a vehicle renders a student liable for a fine of $15 for each offense.

A permit allowing limited driving and parking on the campus throughout the week costs $10 per term. A more restricted permit allowing driving and parking on the campus for evenings and weekends costs only $3.50 per term.

A graduate assistant pays no fee for the privilege of driving and parking on the campus but is required to comply with student regulations concerning motor vehicles. If a student lives for more than thirty consecutive days in the year in Pennsylvania, he shall be required to obtain Pennsylvania registration for his vehicle. A student's spouse may be required to register his or her car in Pennsylvania. A *Student Parking and Traffic Regulations* booklet is available in Room 209 Hetzel Union Building.

STUDENT AIDS

In every case in which a graduate assistantship, fellowship, grant-in-aid, or scholarship for the next academic year is offered to an actual or prospective graduate student, the student, if he indicates his acceptance before April 15, will have complete freedom through April 15 to submit in writing a resignation of his appointment in order to accept one elsewhere. However, an

acceptance given or left in force after April 15 commits him not to accept another appointment without first obtaining formal release for the purpose.

ASSISTANTSHIPS

Approximately 2,100 graduate assistantships are awarded annually. Most of these are half-time, but a limited number of quarter-time and three-quarter-time assistantships are available in some major programs. An appointee may serve as an assistant in classroom or laboratory instruction, or in research or other work.

A prospective student should write directly to the head of his major department or program chairman for information and application forms. Appointments are made upon the recommendation of the department head or program chairman, subject to his admission to the Graduate School as a degree candidate. Clear evidence of superior ability and promise is required. Reappointment to an assistantship is based on availability of positions and the quality of the student's work. In most departments or major programs the number of appointment renewals is limited. A common policy is to limit eligibility to two calendar years of study for a master's candidate or five total years for a doctoral candidate.

The assistantships vary as follows:

QUARTER-TIME — The student may schedule 7-9 credits, receives a stipend in the range $318-$600 per term plus a grant-in-aid which covers tuition, will be required to give a maximum of ten hours of service per week for twelve weeks, and will be considered to be following a full-time course of instruction.

HALF-TIME — The student may schedule 5-7 credits, receives a stipend in the range $630-$1200 per term plus a grant-in-aid which covers tuition, will be required to give a maximum of twenty hours of service per week for twelve weeks, and will be considered to be following a full-time course of instruction.

THREE-QUARTER-TIME — The student may schedule 4-5 credits, receives a stipend in the range $948-$1800 per term plus a grant-in-aid which covers tuition, will be required to give a maximum of thirty hours of service per week for twelve weeks, and will be considered a part-time student.

The credit load limits specified above may be increased or decreased for a specific term by permission of the person to whom the student is responsible for his service assignment, provided the credit load and the service load are properly balanced in each term, and the total credit load over a series of terms is in conformity with the specified limits stated above.

In addition to receiving a grant-in-aid to cover full tuition during the term of appointment, a graduate assistant who is completing three or more consecutive terms of service is entitled to apply for an extra earned grant-in-aid to cover tuition for the succeeding term without service if he is not receiving a scholarship or fellowship from another source during the term. To receive this privilege a student must obtain an extra earned grant-in-aid form from the head of the department or program in which he has held the assistantship and must follow the instructions on the form in making application.

Graduate assistants may accept concurrent employment outside the University only with the permission from the department head or program chairman. He may not hold concurrent employment with the University. He may receive a concurrent fellowship supplement.

A graduate assistant pays no fee for the privilege of driving and parking on the campus but is required to comply with student regulations concerning motor vehicles.

FELLOWSHIPS AND TRAINEESHIPS

More than four hundred fellowships and traineeships are awarded annually. Recipients must be superior students and are frequently required to have completed a certain minimum of graduate work before being eligible for an award. Need is also normally a consideration. Fellows and trainees carry full-time graduate programs, receive stipends which vary with the awards, and receive grants-in-aid paid by the donors of the awards to provide for all tuition. They may not accept employment during the terms of their appointments (except with special

permission for training purposes), nor are they required to render any service to the University. In some cases a recipient will be expected to limit his research to a broad field specified by the donor. Recipients are required to pay specific charges, such as admission, late registration, change of schedule, and parking fees, and also the thesis binding and microfilming fee unless the latter is paid for by the donor of the award.

COMMONWEALTH OF PENNSYLVANIA RESEARCH FELLOWSHIPS — Intended as a means of encouraging students to conduct research on projects of special application to Pennsylvania, awardees are selected from among Ph.D. candidates who will have passed their comprehensive examination before the start of fellowship tenure on the basis of the usefulness of their research to Pennsylvania, on scholarly promise, and on need. These fellowships pay up to $300/month for three to twelve months plus remission of the dissertation fee. Application forms are available in Room 317 Kern Graduate Building.

GRADUATE SCHOOL FELLOWSHIPS — A small number of fellowships, each paying a stipend of $280/month and providing a grant-in-aid to cover tuition charges are given by the University and are designated as Graduate School Fellowships. They are available to outstanding graduate students working toward a doctoral degree in any doctoral program, although, ability of applicants being comparable, some preference is given to students majoring in the humanities and social sciences.

Applications should be addressed to the Graduate School Fellowship Office, 317 Kern Graduate Building, and must be received by the fifth Monday of the winter term to be considered for the following year.

ERIC A. WALKER FELLOWSHIPS, FELLOWSHIP SUPPLEMENTS, AND GRANTS-IN-AID — These are open only to students who have been approved for admission but are not yet enrolled in the Graduate School at the time of application. Full fellowships pay up to $260/month plus tuition. Grants-in-aid provide only tuition. Supplements are small grants in addition to a graduate assistantship or another fellowship. Application forms may be obtained from the Fellowship Office, 317 Kern Graduate Building, University Park, Pa. 16802, and must be submitted by February 20 to be considered for the following fall. Applicants must arrange to have Graduate Record Examination verbal and quantitative scores sent to this address so as to reach the Fellowship Office by February 20.

FELLOWSHIPS AND TRAINEESHIPS FROM SPECIFIC GRANTS TO DEPARTMENTS AND DIVISIONS BY FOUNDATIONS, INDUSTRIES, AND FEDERAL AGENCIES — At least 230 such awards, with various stipends are granted through individual departments. Information and application forms may be secured from the head of the major department concerned. The specific awards will vary somewhat from year to year, but the following are typical of those which were available for 1971-72.

AMELIA EARHART FELLOWSHIP — Available to a woman graduate student in aerospace engineering; stipend $2,400.

AMERICAN CHEMICAL SOCIETY FELLOWSHIP — Available to a graduate student in chemical engineering; stipend $2,844.

AMERICAN CHEMICAL SOCIETY FELLOWSHIPS (2) — Open to graduate students in geochemistry, mineralogy, and solid state science; stipend $2,400.

AMERICAN IRON AND STEEL INSTITUTE FELLOWSHIPS (2) — Open to graduate students in geochemistry and metallurgy; stipend $2,400-$4,320.

ARMSTRONG CORK SUMMER FELLOWSHIPS IN CHEMISTRY (5) — Open to graduate students in chemistry.

ATOMIC ENERGY COMMISSION GRADUATE TRAINEESHIPS IN NUCLEAR REACTION OPERATIONS AND UTILIZATION (6) — Open to graduate students in nuclear engineering; stipends comparable to the AEC Special Fellowships.

BROCKWAY GLASS COMPANY FELLOWSHIP — Available to graduate student in ceramic science whose thesis is in the area of glass science; stipend $3,500-$4,000.

CONTINENTAL OIL COMPANY FELLOWSHIP — Available to a graduate student in chemical engineering; stipend $2,844.

CONTINENTAL OIL COMPANY FELLOWSHIP — Available to a graduate student in petroleum and natural gas engineering for studies in petroleum engineering; stipend $2,280.

CONTINENTAL OIL COMPANY FELLOWSHIP IN PETROLEUM ECONOMICS — Available to a graduate student in mineral economics for studies in petroleum economics; stipend $2,280.

DIAMOND SHAMROCK CORPORATION FELLOWSHIP — Available to a graduate student in chemical engineering; stipend $750.

DU PONT FELLOWSHIP — Available to a graduate student in mechanical engineering; stipend $4,200 per year (4 terms) plus tuition. In addition $1,000 fund is available for student research activity.

DU PONT SUMMER FELLOWSHIPS (6) — Open to graduate students in chemical engineering; stipend $948.

W. S. ELLIOTT FELLOWSHIP — Available to a graduate student who is a graduate of The Pennsylvania State University and is interested in engineering research; stipend $1,200.

ERNST AND ERNST FELLOWSHIP — Available to a master's candidate in accounting; stipend $1,000.

F.I.R.E. — Research in field of thermal/mechanical behavior of refractories. Available to student in ceramic science; stipend $3,000 per year.

HERMAN G. AND SUZANNE G. FISHER FOUNDATION FELLOWSHIP — Available to an advanced graduate student in human development and family studies and especially interested in work with young children; stipend $3,500 for tuition and other expenses.

GENERAL FOODS FUND FELLOWSHIPS (2) — Open to graduate students with a major in the College of Human Development; stipend for doctoral $3,000, for master's $2,000 for tuition and other expenses.

GULF OIL COMPANY FELLOWSHIP IN PETROLEUM AND NATURAL GAS ENGINEERING — Available to a graduate student for work in petroleum production; stipend $2,400.

HASKINS AND SELLS FOUNDATION FELLOWSHIP — Available to a graduate student in accounting; stipend $2,500.

WALTER E. HELLER FELLOWSHIP — Provided by Walter E. Heller & Company, in the amount of $1,000 for a candidate for the degree of Master of Business Administration.

HILL FELLOWSHIPS FOR STUDY IN ANTHROPOLOGY OR HISTORY — Details available from Dean S. F. Paulson of the College of the Liberal Arts, 108 Sparks Building.

HILL FELLOWSHIPS IN HISTORY — Available to graduate students in history for the completion of the Ph.D. dissertation; nonrenewable; stipend $3,300.

H. R. IMBT SERVICES, INC. FELLOWSHIP — For graduate work in civil engineering in the field of civil engineering construction; stipend $3,000.

INTERNATIONAL LEAD ZINC RESEARCH ORGANIZATION FELLOWSHIP — In support of research on the application of lead and zinc compounds to chemical, ceramic, electrical, and allied industries. Available to two students in ceramic science; stipend $3,000.

INTERNATIONAL LEAD ZINC RESEARCH ORGANIZATION FELLOWSHIP — In support of research on the physics and chemistry of lead and zinc compounds. Available to a student in solid state science; stipend $2,540.

JOSEPH M. JOHNSTON MEMORIAL SCHOLARSHIP — Available to a student whose program is related to floriculture; stipend variable.

SAMUEL H. KRESS FOUNDATION — Makes available travel grants and research stipends for American students in art history, architecture, and conservation; for doctoral candidates only.

NATIONAL ENDOWMENT FOR THE ARTS — Available to all students preparing a thesis. Information available from program chairman; stipend $1,000.

NATIONAL STEEL CORPORATION FELLOWSHIP — Available to a graduate student in metallurgy; stipend $2,880.

NORTON COMPANY FELLOWSHIP — Available to a graduate student in ceramic science for research on thermal/mechanical properties; stipend $3,000.

EDWARD ORTON, JR., CERAMIC FOUNDATION FELLOWSHIPS — For graduate research in ceramic science, especially in regard to the firing behavior of classical ceramic compositions; stipend $4,800 (variable).

OWENS-ILLINOIS FELLOWSHIP — Available to graduate student in ceramic science whose thesis is in the area of glass science and technology; stipend $3,000-$3,600.

PENNSYLVANIA COOPERATIVE FISHERY UNIT FELLOWSHIPS (3-4) — Open to graduate students in zoology; stipend $2,400-$2,460.

PENNSYLVANIA ENVIRONMENTAL ENGINEERING AND SCIENCE FELLOWSHIPS — Available to graduate students in environmental studies; $5,400 for stipends, plus tuition and related fees.

PRICE WATERHOUSE FOUNDATION FELLOWSHIP — Available to a Ph.D. candidate in accounting; stipend variable up to $5,000.

PROCTOR AND GAMBLE COMPANY FELLOWSHIP — Available to a U.S. citizen who is a graduate student in chemical engineering; stipend $2,844.

RADIO CORPORATION OF AMERICA FELLOWSHIP — Available to a graduate student in electrical engineering; stipend $2,100-$3,000 for nine months. May be supplemented for an additional three months on application.

REFRACTORIES INSTITUTE FELLOWSHIPS — For graduate research in ceramic science related to refractories; stipend $5,000.

ROCKWELL MANUFACTURING COMPANY FELLOWSHIP — Available to a graduate student in mechanical engineering; stipend $4,200 per year (4 terms) plus tuition. In addition $1,000 fund is available for student research activity.

SEL-REX CORPORATION FELLOWSHIP — Available to a student in ceramic science.

SHUBERT FELLOWSHIP IN PLAYWRITING — Available to a graduate student in theatre arts; stipend $2,500.

EDWIN ERLE SPARKS DISSERTATION FELLOWSHIP IN THE HUMANITIES (1) — Available to doctoral candidate in the humanities (classics; comparative literature, English, French, German; history; philosophy; religious studies; Slavic languages; Spanish, Italian, and Portuguese; speech); stipend $3,500 plus tuition. Apply to relevant department before February 1.

EDWIN ERLE SPARKS FELLOWSHIPS IN THE HUMANITIES (8) — Available to beginning graduate students in the humanities (classics; comparative literature, English, French, German; history; philosophy; religious studies; Slavic languages; Spanish, Italian, and Portuguese; and speech); stipends $2,400 plus tuition. Apply to relevant department before February 1.

SPRAGUE ELECTRIC COMPANY FELLOWSHIP — Awarded through the Materials Research Laboratory.

STACKPOLE FERRITE FELLOWSHIP — Available to a graduate student in ceramic science or solid state science; stipend $3,000.

TEXACO FELLOWSHIP IN ENVIRONMENTAL STUDIES — Available to a graduate student majoring in engineering with environmental emphasis through the Center for Air Environment Studies; stipend $3,000 per year plus tuition.

UNION CARBIDE FELLOWSHIP — Available to a graduate student in mechanical engineering; stipend $4,200 per year (4 terms) plus tuition. In addition $1,000 fund is available for student research activity.

U.S. ENVIRONMENTAL PROTECTION AGENCY OFFICE OF WATER PROGRAMS — Open to students in water quality control in civil engineering. Tuition and fees, $1,000-$3,000; stipend may be available.

U.S. OFFICE OF EDUCATION FELLOWSHIPS — Open to graduate students with undergraduate degree in engineering, physical science, or mathematics who are preparing as technology teachers in technical institutes and junior colleges; stipend $2,400 for 12 months plus an allowance of $500 for each dependent.

U.S. OFFICE OF EDUCATION TRAINEESHIPS IN EDUCATION OF EXCEPTIONAL CHILDREN (28) — Open to graduate students being prepared as leadership personnel in the education of the mentally retarded, the emotionally disturbed, the learning disabled, and in special education administration; stipend $300-$800 per term plus dependency allowance. $150 per term with no dependency allowance. Apply to the head of the Department of Special Education.

U.S. OFFICE OF EDUCATION FELLOWSHIPS IN SPEECH PATHOLOGY AND AUDIOLOGY: WORK WITH THE SPEECH-HANDICAPPED (5); WORK WITH THE DEAF (4) — Open to graduate students specializing in these fields; stipend up to $2,200-$3,200 plus dependency allowance. Apply to the director of the Speech and Hearing Clinic.

U.S. OFFICE OF EDUCATION PROSPECTIVE TEACHER FELLOWSHIPS IN ENGINEERING TECHNOLOGY (7) — Open to students with baccalaureate degree in engineering, physics, or mathematics who have had two years of experience; stipend $2,400 for 12 months plus dependency allowance of $500 each.

U.S. OFFICE OF EDUCATION TRAINEESHIPS IN THERAPEUTIC RECREATION (6) — Open to graduate students majoring in therapeutic recreation; stipend $1,800 (three terms).

U.S. PUBLIC HEALTH SERVICE AIR POLLUTION SPECIAL FELLOWSHIP (POST-DOCTORAL) — Available to post-doctoral scholars in the physical sciences, biological sciences, and social sciences; stipend $6,000-$7,000 plus dependency allowance.

U.S. PUBLIC HEALTH SERVICE TRAINEESHIPS — Available through Departments of Anthropology, Biological Health, and Biophysics.

U.S. PUBLIC HEALTH SERVICE TRAINEESHIPS IN AIR POLLUTION (26) — Open to selected graduate students in the physical sciences, biological sciences, and social sciences; stipend $3,000-$3,600 plus dependency allowance. Applications and information available through the Center for Air Environment Studies.

U.S. PUBLIC HEALTH SERVICE TRAINEESHIPS IN CLINICAL PSYCHOLOGY (15) — Open to selected graduate students in this area of psychology; stipend $2,400-$2,600, plus tuition and dependency allowance.

U.S. PUBLIC HEALTH SERVICE TRAINEESHIPS IN MICROBIOLOGY (4) — Open to selected graduate students in microbiology; stipend $2,400-$2,800.

U.S. PUBLIC HEALTH SERVICE TRAINEESHIPS IN NUTRITION IN PUBLIC HEALTH (4) — Open to first- and second-year students in M.S. program in Nutrition in Public Health; stipend $2,400-$3,600.

U.S. PUBLIC HEALTH SERVICE TRAINEESHIPS IN SOCIAL GERONTOLOGY (12) — Open to selected post-master's graduate students in the social and behavioral sciences; stipend $2,600-$2,800 plus dependency allowance. Apply to director, Program in Adult Development and Aging.

U.S. PUBLIC HEALTH SERVICE TRAINEESHIPS IN VERBAL BEHAVIOR (8) — Open to selected graduate students in this area of psychology; stipend $2,400-$2,800, plus tuition and dependency allowance.

U.S. REHABILITATION SERVICES ADMINISTRATION TRAINEESHIPS IN SPEECH PATHOLOGY AND AUDIOLOGY (11) — Open to graduate students specializing in speech pathology and audiology; stipend $2,400-$3,400.

U.S. REHABILITATION SERVICES ADMINISTRATION TRAINEESHIPS IN THERAPEUTIC RECREATION (6) — Open to graduate students specializing in therapeutic recreation; stipend $1,800 (three terms).

UNITED STATES STEEL FELLOWSHIP — Available to a graduate student in metallurgy; stipend $2,400-$3,600 per year.

U.S. VOCATIONAL REHABILITATION ADMINISTRATION TRAINEESHIPS IN VOCATIONAL REHABILITATION COUNSELING (36) — Open to graduate students in counselor education who are specializing in vocational rehabilitation counseling; stipend $1,800-$2,000.

VETERANS ADMINISTRATION INTERNSHIPS IN CLINICAL PSYCHOLOGY (5) — Open to selected advanced graduate students in this area of psychology; stipend $3,500-$6,500, not including tuition and fees.

WALTER THOMAS MEMORIAL SCHOLARSHIP — Available to a student studying the nutrition of horticultural crops; stipend variable.

ARTHUR YOUNG AND COMPANY FELLOWSHIP (1) — Open to a master's degree candidate in accounting from a predominantly black college.

In addition grants are available from governmental agencies, industrial concerns, foundations, and the armed forces for graduate study, and frequently for support of investigations of particular problems. Some of these permit full-time study and carry the same exemptions as the fellowships listed above. Detailed information may be secured from departments.

EXTERNALLY SPONSORED FELLOWSHIP AND TRAINEESHIP PROGRAMS — Attention is directed to the following national programs, involving numerous fields of study, with which the University cooperates by providing local administration. (See statement on nondiscrimination, page 58.)

ATOMIC ENERGY COMMISSION SPECIAL FELLOWSHIPS IN NUCLEAR SCIENCE AND ENGINEERING — These fellowships are available to United States citizens who hold bachelor's degrees in engineering or physical science (chemistry, earth science, mathematics, or physics) and who have completed mathematics through ordinary differential equations. Applicants for first-year fel-

lowships will be required to take the Graduate Record Examinations, designed to test aptitude and achievement, which are administered in January at a large number of centers in the United States and overseas. Before a fellowship appointment becomes effective, the fellow must be granted fellowship clearance by the Atomic Energy Commission and must be accepted by a participating university for study leading to an advanced degree. The deadline for filing applications for fellowships beginning in September is the first of the preceding January. Forms may be obtained from the NSE Fellowship Office, Oak Ridge Associated Universities, Oak Ridge, Tennessee. About 200 will be awarded.

FEDERAL HIGHWAY ADMINISTRATION FELLOWSHIPS — Provided by the Federal Highway Administration, U.S. Department of Transportation, to develop the expert manpower needed to carry out state and local jurisdiction highway safety programs. Open to engineering graduates for graduate study in highway traffic engineering. Only U.S. citizens are eligible. Fellowships are granted for an academic year at $5,000 each for tuition, books, and living stipends. Application forms are available from the National Highway Institute, 400 7th Street, S.W., Washington, D. C. 20590.

FEDERAL WATER QUALITY ADMINISTRATION FELLOWSHIPS — Are given to encourage research and training related to the causes, prevention, and control of water pollution and the management of water quality. Application is made directly to the Training Grants Branch, Washington, D.C. 20242. Fellowships are coordinated through the Graduate School Fellowship Office for those awardees who attend The Pennsylvania State University; stipend $2,400-$2,800.

FORD FOUNDATION — 320 East 43rd Street, New York, N. Y. 10017 — Offers doctoral fellowships for beginning American Indian, Mexican-American, Puerto Rican, and Black students. (Black students should apply through the National Fellowships Fund for Black Americans, 795 Peachtree St. N.E., Suite 484, Atlanta, Ga. 30308.) Each fellowship includes a monthly stipend of $250, tuition, a book and supply allowance, and a dependency allowance. Dissertation-year fellowships for up to $5,000 are also available for research on the history and culture of these ethnic groups, Asian-Americans, and on the role of women in society. Applications must be submitted through the Graduate School Fellowship Office, 317 Kern Graduate Building, by February 14.

HOUSING AND URBAN DEVELOPMENT GRADUATE FELLOWSHIPS — For the graduate training of professional city planning and urban and housing technicians and specialists; carry stipends of $3,000 per year plus tuition plus $500 per dependent. About 100 are awarded annually in national competitions. Application forms are available from Graduate Program in Regional Planning, 213 Willard Building, and must be completed and filed by January 31 for study starting the following September.

INTERNATIONAL UNIVERSITY FELLOWSHIPS IN SPACE SCIENCE — These graduate and post-doctoral fellowships are available to foreign nationals who hold the equivalent of master of science or master of engineering degrees and meet graduate student entrance requirements at United States universities. Details on the program will be found in the brochure concerning these fellowships issued by the Office of Scientific Personnel, National Academy of Sciences, Washington, D. C. 20418

NATIONAL DEFENSE MODERN FOREIGN LANGUAGE FELLOWSHIPS — Under Title VI of the National Defense Education Act of 1958, as amended, the U.S. Commissioner of Education allocates to institutions which have approved programs of study in certain languages of critical importance to the United States, and in the cultural areas related to these languages, graduate fellowships for the study of these languages and the related areas. The languages involved in this program are in general those not commonly taught in the United States. French, German, Italian, and Peninsular Spanish are excluded.

Applicants must give reasonable assurance that they will be available after graduate study for teaching a modern foreign language or a related study in a college in the United States or for such other public service as may be specified in the application materials.

In 1972-73 the University awarded four fellowships in Russian language and area studies for majors in Slavic languages, in the Eastern European program for students majoring in Russian, and for those majoring in art history, economics, geography, history, or political science, with

emphasis on Eastern Europe but also studying a Slavic language. Write to the head of the department of one of these six graduate programs.

NATIONAL SCIENCE FOUNDATION GRADUATE FELLOWSHIPS — The Graduate School cooperates in this program of prestige fellowships requiring outstanding credentials and available in the biological, engineering, mathematical, and physical sciences; anthropology; economics (excluding business administration); geography, history and philosophy of science; political science; psychology (excluding clinical); and sociology (excluding social work). Also included are interdisciplinary programs such as biophysics, geochemistry, genetics, and physiology. These fellowships are used at the university of one's choice. Application is made during the fall to the Fellowship Office, National Academy of Sciences-National Research Council, 2101 Constitution Ave., N.W., Washington, D.C. 20418, which has charge of evaluating applicants for the Foundation. About 1,000 new awards were made for 1972-73. The stipend is $300/month for three years plus remission of tuition. The application deadline for 1973-74 was November 27, 1972.

OTHER AIDS

GRADUATE SCHOOL TUITION GRANTS-IN-AID — Forty grants for full-time study are awarded each year on a term basis, providing for all tuition. They are available to any graduate degree candidate in his third or a later term at this University on criteria of financial need and academic promise. A recipient is to carry a full program of graduate work but may accept employment with the University or another employer not to exceed ten hours per week, provided he reduces his academic load to 8 or 9 credits. Application for renewal of the grant-in-aid may be made for succeeding terms. The value of these grants to Pennsylvanians is $300 per term, and to non-Pennsylvanians, $700 per term. Applications for grants for the winter, spring, and summer terms must be filed by the fifth week of the preceding term and by April 20 for the fall term. Applications should be addressed to the Office of Graduate School Fellowships, 317 Kern Graduate Building.

PHI KAPPA PHI GRANTS-IN-AID — One or two tuition grants-in-aid in each of spring and summer terms are available for students completing degree requirements during the term of the award. Application procedures are the same as for Graduate School Tuition Grants-in-Aid.

THE RUTH YOUNG BOUCKE GRADUATE FELLOWSHIP — Established from the estate of Ruth Young Boucke, whose husband was for many years a professor of economics, this fellowship is available every other year to an outstanding graduate student on the same basis as the regular Graduate School fellowships, and selection is made by the Graduate School Committee on Fellowships and Awards. The stipend is up to $2,520 for a tenure of three terms plus a grant-in-aid of tuition.

LUCRETIA V. T. SIMMONS SCHOLARSHIP — The State College Chapter of the American Association of University Women has established a modest scholarship which is awarded annually to honor an outstanding woman graduate student. The award does not include exemption from tuition. Nominations are made by departments. Stipend variable.

LOAN FUNDS — Funds from two sources are available to graduate students. Application forms may be obtained from the Office of Student Aid, Grange Building.

UNIVERSITY LOAN FUNDS have been established through University organizations, alumni, faculty, staff, and friends. Applicants must demonstrate need for financial assistance in meeting University-related expenses, and must be United States citizens. International students, however, may qualify for short-term loans if they can enlist responsible residents of Pennsylvania as cosigners of the notes. The interest on long-term loans does not begin until after graduation and is generally at a low rate for the first two years.

NATIONAL DIRECT STUDENT LOANS are available for United States citizens from the federal government. Evidence of need must be supported by a Confidential Statement. Interest,

at three percent, does not start until nine months after the borrower ceases to be a full-time student.

STATE HIGHER EDUCATION LOAN PLANS — Some States have passed laws that enable them to set up agencies to guarantee loan agreements with commercial banks, enabling co-operating banks in those states to make long-term personal loans to qualifying students to help pay their college or graduate school expenses. This cooperation makes possible lower interest charges and longer repayment periods than are available for ordinary personal loans.

Pennsylvania has established the Pennsylvania Higher Education Assistance Agency for those who are residents of Pennsylvania and have been accepted for enrollment in an approved institution of higher education. A full-time graduate student may borrow up to $2,500 per year, the total not to exceed $7,500 during the entire period of his post-secondary education. A part-time graduate student is limited to $750.00 per year and, to be eligible, must be enrolled for at least 6 credits. Evidence of need must be supported by a Confidential Statement. A list of participating lending institutions is available from all secondary school counselors, school financial aid officers, or the Pennsylvania Higher Education Assistance Agency, Guaranteed Loan Program, Towne House, Harrisburg, Pa. 17102.

Residents of other states should communicate with their state education departments regarding the existence of similar plans. Practically all the states and the District of Columbia have such programs.

GIRARD EDU-CHECK PLAN — The University offers to sponsors (including parents) of students the Assured Education Plan, enabling them to pay out of current income, on a monthly basis, University bills for tuition, residence hall room and board, and all other items billed by the University. Life insurance and total and permanent disability insurance are a part of the plan for the sponsor up to his sixty-eighth and sixty-first birthdays, respectively. Payments are handled through the Girard Bank, 2nd and Chestnut Streets, Philadelphia, Pa. 19106. Further information and application forms may be obtained from the Office of the University Bursar, 103 Shields Building. Signed agreements should be received well in advance of registration, since it takes at least three weeks for completion of arrangements.

STUDENT EMPLOYMENT — Many students depend upon part-time employment to help meet their expenses. A student who is thus employed, however, must recognize the time demands of his work schedule and will be required to adjust his academic load accordingly. The Office of Student Aid offers assistance in finding part-time employment in town as well as on campus, and through the Federal College Work-Study program. For participation in the College Work-Study program, evidence of need must be supported by a Confidential Statement.

The State College Chamber of Commerce also gives assistance to students concerning part-time employment. The Chamber of Commerce, local placement services, and the University Office of Personnel maintain files of positions open to wives of students. Many local residents seek help for baby-sitting, housework, typing, and other general kinds of employment.

A student holding a fellowship, traineeship, or scholarship may not accept employment of any kind for service beyond that specified by his appointment. Graduate assistants may accept concurrent employment outside the University only after obtaining permission from the department head or person in charge of his major program. He may not hold a concurrent appointment with the University other than a Fellowship Supplement.

VETERANS' BENEFITS — The Coordinator of Veterans Affairs has the responsibility of handling all applications for benefits under the various public laws.

Under P. L. 89-358, a student is classified as full-time if he registers for 8 or more credits.

After each term's registration, the number of credits scheduled must be reported to the University Coordinator of Veterans Affairs for enrollment certification to the Veterans Administration.

Recently discharged servicemen not in this area may obtain information on veterans' educational benefits under P. L. 89-358 and its recent revision from the Veterans Administration representatives at their local county courthouse.

PROCEDURES AND REGULATIONS

A student is expected to assume full responsibility for knowing the regulations and pertinent procedures of the Graduate School as set forth in the publications, the *Manual for Graduate Students* and the *Thesis Information Bulletin,* and for meeting the standards and requirements expressed by these regulations. The *Manual,* which is available to a student after he has been admitted, sets forth in more detail the procedures governing registration, changes in program, and graduation, and gives other information about the Graduate School which is useful to graduate students. Every student should secure a copy from the Office of the Dean soon after admission.

STATEMENT OF NONDISCRIMINATION

In the selection of individuals for graduate study, in which the University has partial or complete control of the selection process and administration of the program, the University will not discriminate on the basis of race, creed, color, sex, or national origin of any applicant.

ADMISSION

An applicant for admission to the Graduate School should understand that graduate work is not a simple extension of an undergraduate program. It operates at a higher level, demands scholarship of a higher order, and emphasizes research, creativity, and professional competence with a minimum of formal requirements and a maximum of student initiative and responsibility.

Objective — The objective of the Graduate School is to admit a graduate student body of high qualifications up to the limit of the University's resources to provide graduate programs of outstanding quality. In general, a student may begin his graduate work in fall, winter, spring, or summer.

Applicants must recognize that staff, facilities, and other resources are limited so that not all qualified persons can be admitted. The number accepted will vary by program and from term to term. In some graduate programs all vacancies will have been filled long before the deadline for submitting applications so that even outstanding students cannot be accepted.

Application — Students are normally expected to begin work at the University Park Campus unless they have been admitted to an approved graduate program offered at Behrend or King of Prussia Graduate Centers or the Capitol Campus. Applicants interested in programs offered at these locations should apply directly to the appropriate campus. Applicants for the University Park Campus or The Milton S. Hershey Medical Center should apply at University Park. Any exception to this policy must be approved jointly by the graduate department head or program chairman and the Office of Graduate Admissions.

Requirements — For admission to the Graduate School an applicant must have received a baccalaureate degree from an accredited institution, earned under residence and credit conditions substantially equivalent to those required by The Pennsylvania State University. He must ordinarily have completed in a satisfactory manner a certain minimum of course work in designated areas, the specific courses and amount of work depending upon the field of advanced work which the student proposes to enter.

A student with a slight deficiency in undergraduate preparation may be admitted and allowed to take a limited number of undergraduate courses to make up the deficiency while proceeding with his graduate program. Courses taken for this purpose do not, of course, apply toward the requirements of the advanced degree.

Admission may be granted to applicants whose credentials are not complete at the time of application because the baccalaureate degree has not yet been conferred, grades for the current term are not yet available, etc. Such admission is subject to cancellation if the complete credentials, on arrival, do not meet the requirements for admission. In the interim, certification of any earned credits will be withheld. If admission should, for any reason, be canceled, the student is thereby automatically dropped from the Graduate School.

Admission is granted jointly by the Graduate School and the department or graduate program in which the student plans to follow his studies. The establishment of standards by which

applicants are admitted is a departmental or program responsibility. Though the Graduate School has no fixed minimum grade-point requirement for admission, an applicant is generally expected to maintain during his junior and senior years quality in his work equivalent to a grade-point average of at least 2.50 on The Pennsylvania State University grading scale of A (4) to D (1). Individual programs may establish higher grade-point averages and other criteria by which they will judge candidates for admission. Departments or major programs may also, in exceptional cases, approve admission by reason of special backgrounds, abilities, and interests. Departmental or program requirements are given in the descriptive statements appearing under the major programs listed in the latter part of this publication.

The above requirements apply particularly to the student who recently completed an undergraduate program and is about to begin graduate study. An applicant who has obtained a graduate degree at a recognized graduate school will be evaluated largely on the basis of the graduate record.

A student who has been admitted to a program in which the doctorate is offered may begin working toward that degree, but he has no official status as a doctoral student and no assurance that he will be accepted as a doctoral candidate until he has passed a candidacy examination administered by his major department or committee.

Forms — Forms to be used in applying for admission can be obtained from the Office of Graduate Admissions. Applicants may apply for admission to only one program at a time. All academic records, and explanation of the grading system used, should be submitted, *in duplicate,* to the Office of Graduate Admissions, 310 Kern Graduate Building. These must be received from all institutions by the Graduate School at least one month prior to the opening of the term in which the student plans to begin his graduate program.

Deadlines — The deadline for processing of applications by the Graduate School is one month prior to the beginning of a specific term. GRADUATE MAJOR PROGRAMS MAY REQUIRE EARLIER DEADLINES. A complete Graduate School admissions file, which is required for processing an application, includes the following items: (1) application blanks, (2) application fee form, (3) a check or money order in the amount of $15.00 made payable to The Pennsylvania State University, and (4) duplicate transcripts from each institution of higher education attended. This applies to the complete academic record, both undergraduate and graduate. Supplementary materials and examination scores may be required in individual programs. If the admission file is incomplete a month prior to the beginning of the term for which the student has applied, his materials will be processed for the first term following the completion of his admissions file.

Nondegree — A student who plans to take courses for transfer to another institution or to follow a program of study not leading to an advanced degree at this institution should apply for admission as a nondegree student. The adviser for such a student may be appointed by the department head or program chairman most closely associated with the student's field of interest. The number of nondegree students which can be admitted is limited because preference is given to students in degree programs.

Foreign Students — Foreign students should plan on applying at least six months prior to the beginning of the term. They must submit certified English translations of all academic records. Since in many programs the TOEFL score is required, this must accompany the application for admission. Foreign students are not admitted as nondegree students unless sponsored by an agency.

UNDERGRADUATE STUDENTS — A senior student of The Pennsylvania State University lacking not more than 4 credits for graduation may be admitted to the Graduate School. This limit may be increased to 8 credits in the case of a student with an average of at least B (a grade-point average of 3.00). Any senior with a 3.50 grade-point average may be admitted to 500-level courses with the consent of the instructor; other undergraduate students with a B average or better may be admitted to such courses with the consent of the instructor and the Dean of the Graduate School.

In certain cases undergraduate students may subsequently apply credits they have earned in 400- and 500-series courses toward an advanced degree at The Pennsylvania State University. Upon admission to the Graduate School such credits as are relevant to the graduate program

of study and were not used to satisfy undergraduate requirements will be entered on the student's graduate transcript. These may then be applied toward an advanced degree provided they are acceptable to the major program and minor field. The time limitation on the completion of a master's degree program applies to these as well as to other credits.

GUESTS OF THE UNIVERSITY — It is the policy of this Graduate School not to permit applicants to work for a second doctoral degree. The President, on recommendation of the Dean of the Graduate School, will welcome as guests holders of earned doctor's degrees who may be visiting the University Park Campus for purposes of noncredit study. Guest privileges apply to persons holding the degree from The Pennsylvania State University or other accredited colleges and universities. Guests may attend seminars and courses and, if space and facilities are available, carry on research. There will be no charge except for laboratory expenses. Arrangements should be made in advance with the Dean of the Graduate School.

STUDENT RESIDENT STATUS — Whenever it appears that an applicant for admission is not domiciled in Pennsylvania, it is assumed that he is a non-Pennsylvanian. If a student who is thus admitted believes that his circumstances do not justify his classification as a non-Pennsylvanian, he may petition the Dean of the Graduate School through the Financial Officer, 316 Kern Graduate Building, for reclassification.

When a petition for reclassification is made, the petitioner is required to present proof of a bona fide continuous domicile (other than as a student) within the Commonwealth for a period of at least 12 months immediately preceding the date of registration for courses, or such other evidence as is pertinent to a complete review of his classification.

Any student who changes his domicile while attending the University is subject to reclassification effective at the beginning of the first term following notification to the Graduate School that such a change has been made.

Registering to vote in Pennsylvania does not in itself affect a student's classification as a non-Pennsylvanian. Tuition reduction entitlement is determined by residence at the time of admission.

CLASSIFICATION OF STUDENTS

A graduate student may be admitted either as a degree student or as a nondegree student, depending upon his objectives. After admission to one of these categories, any change to the other must be arranged through the Office of Graduate Student Programs.

DEGREE STUDENTS — A degree student is one who plans to become a candidate for an advanced degree at The Pennsylvania State University and who has been formally admitted for advanced studies in a particular program. The program of study is developed under the guidance of an adviser appointed by the head of the student's major program. A degree student who has passed a candidacy evaluation is classified as a doctoral candidate.

NONDEGREE STUDENTS — An applicant who meets all requirements for admission to the Graduate School, but who does not wish to work for an advanced degree at this institution, may arrange for a program of work as a nondegree student. This classification includes any who plan to transfer credits to another institution and those who plan special programs of study not leading to an advanced degree. The number of nondegree students who can be admitted is limited, and it is increasingly difficult to provide for them because of the limitation of total enrollment. Preference is given to students in degree programs.

Nondegree students who are applying for admission to the University Park Campus *must* submit two transcripts from each institution attended. Transcripts should be sent to the Office of Graduate Admissions, 310 Kern Graduate Building, The Pennsylvania State University, University Park, Pa. 16802.

The admission of a nondegree graduate student at the University Park Campus will be subject to the recommendation of the program chairman or head of the department in which he proposes to do most of his work or in which his major interest lies. Casual students with broad interests, not easily identifiable with a single program, may be admitted directly by the Graduate

School. Applications and credentials must be received at least one month prior to the anticipated term of enrollment.

ADJUNCT STUDENTS — An adjunct student is not a graduate student, inasmuch as he has not earned a baccalaureate degree, and may not register for graduate courses or research (500 and 600 series) without permission of the Dean of the Graduate School. An adjunct student may register for 400-level courses provided he has attained at least junior standing in college. He is admitted through undergraduate admissions.

Credits earned as an adjunct student may not ordinarily be applied subsequently toward an advanced degree.

PROGRAMS

MAJOR PROGRAM — A student's major program is his field of primary interest and the one in which the greater portion of his work is taken. Programs are designed to prepare the student to assume a position of informed and responsible authority in his field and to contribute creatively to it. They promote not only specialization, but also breadth of scholarship, the ability to study and think independently, and familiarity with the principal techniques and important literature in the field. The research undertaken by the candidate should deal with a problem that is truly significant and represents research at its best.

INTERDISCIPLINARY MAJORS — In addition to the graduate major programs listed in this bulletin, interdisciplinary majors involving two or more departments within a single college or intercollege majors involving two or more colleges may be arranged with the approval of the Dean of the Graduate School. These programs are offered under the supervision of appropriate interdepartmental or intercollege committees.

In general, departments of the University are identified with specific major programs. Thus aerospace engineering is a major program of study which is offered under the supervision of the Department of Aerospace Engineering. On the other hand, engineering acoustics and genetics are major programs for which there are no corresponding departments. In such cases, a committee of the Graduate School is responsible for administering the program. In some cases a single department offers work in more than one program. Thus the Department of Material Sciences offers work in ceramic science, fuel science, metallurgy, and mineral processing.

Applicants for admission are encouraged to consult the person whose name is listed under the major program heading.

MINORITY STUDENTS — Different colleges and departments offer graduate study relating to minority students, and financial assistance is sometimes available. Information may be obtained from the deans of the colleges or through the graduate programs of the students' major interests.

ADVANCED DEGREES OFFERED

The degrees of Doctor of Philosophy and Doctor of Education are conferred by the University. Both require high attainment and productive scholarship, but the Ph.D. places a strong emphasis on research, whereas the D.Ed. emphasizes professional competence in some field of education or teaching.

The Master of Arts and the Master of Science degrees are academic in nature, the programs placing strong emphasis on basic knowledge and research. The professional master's degrees conferred are the Master of Administration, Master of Agriculture, Master of Business Administration, Master of Education, Master of Engineering, Master of Environmental Pollution Control, Master of Fine Arts, Master of Forestry, Master of Nursing, Master of Public Administration, and Master of Regional Planning.

A candidate for the M.Adm., M.Eng., or M.P.A. degree may meet all the requirements for his degree at a Graduate Center or the Capitol Campus of The Pennsylvania State University provided the major program head or supervising committee and the Dean of the Graduate School have agreed that a complete program of study leading to the specific degree can be

pursued at these locations. Thus a complete program leading to the degree of Master of Engineering with a major in engineering science has been approved for the Behrend Graduate Center, the King of Prussia Graduate Center, and the Capitol Campus. Such designation of location of the completion of the program will be noted on the student's transcript.

CHANGE OF DEGREE OR PROGRAM

A graduate student who has been admitted for work in one major program, but wishes to transfer to another, should submit his request to the Office of Graduate Student Programs of the Graduate School. The student's credentials will be reviewed and the proposed new major department head or committee chairman consulted. If the change is approved, the student may be required to make up certain undergraduate deficiencies if he is inadequately prepared for the new major.

A graduate student admitted for either an academic degree (M.A., M.S., or Ph.D.) or a professional degree (M.Adm., M.Agr., M.B.A., M.E.P.C., M.Ed., M.Eng., M.F., M.F.A., M.N., M.P.A., M.R.P., or D.Ed.) who wishes to change to another type of degree program must apply to the Office of Graduate Student Programs of the Graduate School for the transfer. Similarly, a student who has earned a master's degree must apply for a formal transfer if he plans to work for a doctor's degree of a different type. A student may be required to make up certain deficiencies if inadequately prepared for the new program.

GRADUATE CREDITS

It is important that the student understand that in the Graduate School the word "credit" has no meaning other than as a unit of time — time spent in residence and in off-campus graduate work. One credit stands for the equivalent of approximately one week of full-time graduate work, and 10 credits for a term's work.

Typically, a candidate for an advanced degree is required to earn a certain minimum number of credits at The Pennsylvania State University. Consequently, there is a limit to the number of credits he may earn at another approved institution or through continuing education to meet the minimum requirements of his degree. Moreover, the department or committee in charge of a major program may require a student to do more of his work at the University than specified by the limitations set by the Graduate Faculty.

CONTINUING EDUCATION — A large number of courses carrying credit are given throughout the Commonwealth of Pennsylvania by Continuing Education. All 400-series courses so offered carry graduate credit for students who have been admitted to the Graduate School. The adviser's signature is required on the official registration form, which the student submits at the designated place of registration for the course.

There is no limit to the number of graduate credits which a student may earn in Continuing Education, but not more than 10 credits so earned may be applied toward the minimum requirements for an advanced degree.

REGISTRATION

The responsibility for being properly registered rests with the student. At least until his program is near completion, he is expected to register for each term in which he proposes to do either course work or research toward his thesis, whether it be on or off campus. In the case of research, the number of credits shall be determined by the amount of time required for the investigation, one credit representing the equivalent of one week of full-time work. In the later stages of his program the situation will determine the requirements for the student's registration.

ADVISERS — To assist the student in planning his program, the head of his major department or program chairman will designate a member of the faculty to serve as adviser. It is the student's responsibility to secure the name of his adviser from the department head and to seek a conference before registration.

TIME OF REGISTRATION — Registration days are indicated in the calendar at the beginning of this bulletin.

A student is expected to complete his registration during the officially designated period and to attend the first meeting of all classes in which he is enrolling. If this is impossible because of some emergency or unusual circumstance beyond his control, the student may be granted permission by his instructor to miss a few class meetings, it being understood that work missed will be made up subsequently. Under these conditions the Dean of the Graduate School may grant the student permission to register late. In general, a student who receives permission to register late will be required to reduce his program in proportion to the length of time he has been absent.

Regardless of when he may begin attending classes, a student who fails to complete the process of registration within the officially designated registration period will be liable for the late registration charge.

CONTINUITY OF REGISTRATION — A student who registers at University Park without interruption for each of the three terms in the September to June interval, for all four terms each year, or for each summer term is considered to have maintained a normal continuity of registration.

Anyone who has interrupted such a normal sequence and now plans to register for work at the University Park Campus is required to apply to the Dean of the Graduate School at least one month before the time of registration for permission to resume study.

The policy may be summarized for any specific term as follows:

Summer Term — Application required unless the student was registered at University Park for the preceding spring term or the preceding summer term.

Fall Term — Application required unless the student was registered at University Park for the preceding summer term or the preceding spring term.

Winter Term — Application required unless the student was registered at University Park for the preceding fall term.

Spring Term — Application required unless the student was registered at University Park for the preceding winter term.

PROCEDURE — For each registration the student, in consultation with his adviser, prepares a schedule of courses and research designed to fit his individual needs. The credit load will be reviewed by the Dean of the Graduate School at the time of registration. The registration process is completed in the manner specified for all students at the University.

Under certain conditions credit may be earned by work done away from the campus. A student contemplating such work should inquire of the Dean of the Graduate School about the procedures and conditions. The student must assume responsibility for the registration process, but the operation can be handled by mail. Registration must be completed before the close of central registration at University Park.

A student must register for courses audited as well as for those taken for credit.

REGISTRATION NEAR THE COMPLETION OF A PROGRAM — A candidate for the Ph.D. degree who is following the new regulations, which went into effect in the fall term 1967, is required to register continuously (at least three terms per calendar year) from the time he has both passed the comprehensive examination and met the three-term full-time academic requirement until his thesis is accepted by his doctoral committee, regardless of whether he is working on his thesis during this interval. These candidates are also required to be registered for the term in which they graduate.

Other doctoral candidates and master's students may be required to register for a normal credit load because of their appointment status. If not, and if they have earned more than 90 or 30 credits, respectively, and have met the requirements for their degrees except for the completion of the thesis, these students may register for as few as two credits per term. A student who has met the minimum requirements for his degree and is now completing his research and thesis writing off campus is not required to register, even if he comes to the campus several times each term to see his adviser.

A student, other than one following the new Ph.D. requirement, is not required to register for his final term in order to graduate or in order to make minor revision to his thesis and/or to take a final examination for his degree.

VISITING AND AUDITING CLASSES — A graduate student who wishes to attend classes without receiving credit may secure permission either to visit or to audit courses during a term for which he has registered.

As a vistor, a student may attend classes with the approval of the instructor but may not claim the usual privileges of class membership such as participating in discussion, doing practicum work, or taking examinations. He does not register for the privilege of visiting, nor does any record appear on his transcript.

As an auditor, a student may participate in class discussion, do practicum work, take examinations, and generally share the privileges of a class member. The student registers in the same manner as if he were taking the course for credit and pays the same fees. He receives no credit and cannot subsequently secure credit for work done in the course; however, the Records Office shows on the grade report and the record the actual number of credits assigned to the course. Thus, when a student receives an audit grade, the number of credits which he audited is shown.

A student who, because of his status as a graduate assistant or fellow, is required to register for a certain minimum number of credits is not permitted to count those courses for which he is registering as an auditor for this purpose. The 1G and 2G language courses are an exception. Beyond the required minimum he may register for credit or audit but may not exceed the normal maximum without special permission.

In general, students are encouraged to visit classes rather than to register for a course as auditors. However, visiting is not permitted in German 1G and 2G.

In the 1G and 2G courses offered by the language departments, no distinction is made between registering for credit and for audit in considering loads. If the student does not have a reasonable background in the language, he will be required to count the course as part of his permissible load regardless of whether he registers for credit or for audit. If he has had the language before and is taking the course as a refresher, he may, with the permission of the Graduate Dean, take the course as an overload regardless of whether he registers for credit or audit.

RESEARCH AND THESIS WORK — In registering for thesis work a student uses the appropriate number (600, 601, 610, or 611) preceded by the abbreviation designating his major field. Thus, ENGL 600 denotes thesis research in English being done on the University Park Campus and ENGL 610 thesis research in English being done off campus.

The numbers 601 and 611 are available only to Ph.D. candidates who are following the new regulations, have passed the comprehensive examination, and have met the three-term, full-time academic requirement. Such a candidate in engineering mechanics will register for E MCH 601 if he will be using University facilities and/or faculty services or for E MCH 611 if he will be off campus and requiring little or no faculty service.

It should be assumed that 600 and 610 are available to all graduate major programs and that 601 and 611 are available in all programs approved for the Ph.D., although these numbers may not always appear in the *Schedule of Classes* for each term.

COMMON COURSES — The following courses for which students may register have been set up for common use by major programs, with Senate approval, to encourage innovation and provide flexibility in designing graduate programs:

590. COLLOQUIUM (1-3) Continuing seminars which consist of a series of individual lectures by faculty, students, or outside speakers.

596. INDIVIDUAL STUDIES (1-6) Creative projects including nonthesis research, supervised on an individual basis and which fall outside the scope of formal courses.

597. SPECIAL TOPICS (1-6) Formal courses given on a topical or special interest subject which may be offered infrequently; several different topics may be taught in one year or term. A

specific title may be used in each instance and will be entered on the student's transcript. Multiple offerings may be accommodated by the use of suffixes (a), (b), etc.

LOADS, ACADEMIC AND EMPLOYMENT — To provide flexibility in arranging loads for graduate assistants and full-time University staff members, a procedure has been set up whereby the normal credit limits may be changed by permission of the person to whom the student or staff member is responsible for his service assignment or University employment. Responsibility for the consequences of a graduate student's changing his course load rests with the student and his adviser. The course load is a factor in determining whether a graduate student is classified as a full-time or part-time student; has established residency requirements; and is eligible to hold a fellowship, scholarship, assistantship, or departmental or program appointment.

The University takes the position that the facilities of the Graduate School should be made available only to students who can profit from their graduate school experience to the maximum extent. More than doing what is required in courses or in research, the graduate experience is one of living in a scholarly atmosphere and seriously engaging in scholarly pursuits. It means profiting from hearing visiting scholars and artists and from engaging in discussions, both formal and informal, with faculty members and fellow students. It is an involvement and participation in student affairs, University and Graduate School governance, committee assignments, and personal contribution of effort to the welfare and betterment of the University graduate community. It should mean leisure time for reflection and for exploring fields related to, although not directly a part of one's specialty. Students who propose schedules of few credits not requiring serious effort, or those who wish to carry overloads of such proportion as to handicap them seriously in achieving maximum quality find it difficult and often impossible to experience the satisfaction of a well-rounded scholarly attainment.

Thus a graduate student should strive for a balance between his academic load, employment, or appointment which will classify him as a full-time graduate student with all the privileges and responsibilities intrinsic to this classification, and he should be so certified by his department head or program chairman.

FULL-TIME ACADEMIC LOADS — In establishing credit loads, a student is classified as full-time in any term for which he is registered for 8 to 10 credits, *or* holds a quarter-time assistantship and schedules 7 to 9 credits, *or* has a half-time graduate assistantship and schedules 5 to 7 credits. A three-quarter-time assistant may schedule 4 to 5 credits and is classified as a *part-time* student. A Ph.D. candidate following the new regulations and registered for noncredit 601 or 611 will be classified as full-time if he is not employed in other work and if he is so certified by his department head or program chairman.

PART-TIME ACADEMIC LOADS — A student is classified as part-time in any term for which he is registered for less than 8 credits unless he holds a half-time or quarter-time assistantship.

STAFF EMPLOYEE CREDIT LOADS — A full-time staff employee of the University may schedule 4 credits (up to 16 credits per academic year) per term, either for credit or audit.

No member of the faculty in one of the professorial ranks in the University may receive from the University the master's degree or the doctoral degree.

For University staff employees desiring to take graduate degree work, admission to the Graduate School is a first essential.

EMPLOYMENT — Many students depend upon part-time employment to help meet their expenses. A student who is thus employed, whether on campus or off campus, must recognize the time demands of his work schedule in planning his academic program. A student holding a fellowship or scholarship may not accept employment of any kind for service beyond that specified by his appointment. Graduate assistants may accept concurrent employment outside the University only after obtaining permission from the head of the department providing the assistantship or from the person in charge of his graduate program. A graduate assistant may not hold a concurrent appointment with the University other than a Fellowship Supplement.

COURSE NUMBERING SYSTEM — Courses in the series 1-399 are not listed in this bulletin because they are strictly undergraduate and yield no graduate credit. A graduate student may register for or audit these courses in order to make up deficiencies or fill in gaps in his earlier education but not to meet requirements for an advanced degree.

Courses in the series 400-499 are for upperclassmen with at least junior standing and for graduate students. Only a limited number of credits earned in these courses may be counted toward the requirements for an advanced degree. Detailed regulations concerning the restrictions are given on pages 73-79 under the specific requirements for the various master's degrees.

Courses in the series 500-599 are restricted to students registered in the Graduate School, seniors with an average of at least 3.50, and other students who have been granted permission to enroll by the Dean of the Graduate School.

The numbers 600 (on campus) and 610 (off campus) are available for credit in thesis research in all graduate major programs. The numbers 601 and 611 do not denote courses but are used for noncredit registration by a Ph.D. candidate who is following the new regulations which went into effect in fall term 1967. Registration under these numbers will maintain his status as a student during the interval which begins at the time he has both passed the comprehensive examination and met the three-term, full-time academic requirement and ends at the time his doctoral committee accepts the thesis. The student will register for 601 if he will be using University facilities and/or faculty services; he will register for 611 if he will be off campus and requiring little or no faculty service. Candidates for the Ph.D. degree do not receive grades for noncredit registrations (601 and 611).

SCHEDULE OF COURSES — A complete list of the courses which will be offered in any specific term is given in the *Schedule of Classes,* which is available at nominal cost from the Scheduling Office approximately four months before the beginning of the term. It gives the number of credits being offered in each course, the hours at which the class will meet, the location of the class, and in some cases the instructor's name.

GRADING SYSTEM

A grade is given solely on the basis of the instructor's judgment as to the student's scholarly attainment.

The following revised grading system is now in effect: Any one of five quality grades (A, B, C, D, F) may be given a graduate student for course work or for thesis research. The grade-point equivalents are 4, 3, 2, 1, 0, respectively.

At the 400, 500, and 600 levels grades of A, B, and C denote graduate credit, whereas D and F are failing grades for graduate students, D being the normal failing grade. A grade of F indicates doubt in the judgment of the instructor of the student's potential for further graduate study.

A minimum grade-point average of 3.00 for work done at the University is required for graduation in the case of all candidates whose first registration for graduate study at the University occurred in the spring term 1964 or later.

In addition to the quality grades listed above, two symbols, "Def." (deferred) and "R," may appear on a student's transcript. If work is incomplete at the end of a term for a reason beyond the student's control, or if very little work remains to be done, the instructor may report "Def." in place of a grade, which will appear temporarily on the student's record.

In the case of thesis work, either in progress or completed, and certain courses approved by the University Senate, the instructor may report the symbol "R" in place of a grade. This symbol indicates that the student has devoted an adequate amount of time to the work scheduled but gives no indication of its quality. When reported for thesis work, this symbol will not influence the grade-point average and remains on the student's transcript permanently if not converted to a quality grade (A, B, C, D, or F) within one term of its recording. Quality grades reported for a given term for thesis work will be included in the cumulative grade-point average. Quality grades reported for research will not apply to R's given for earlier registrations and will not denote the quality of an entire series of R's.

UNSATISFACTORY SCHOLARSHIP

A graduate student who fails to maintain satisfactory scholarship or to make acceptable progress in his degree program will be dropped from the University. Action may be initiated by the department or committee in charge of the graduate major or by the chairman of the student's doctoral committee.

GRADUATION

It is the responsibility of the student to inform the Graduate Recorder of his intention to graduate (by filing a diploma card) and to pay the thesis fee at the beginning of the term in which he expects to receive an advanced degree. If he does not graduate that term, he must reactivate the diploma card by indicating to the Graduate Recorder the term in which he intends to graduate. Deadlines are given in the calendar found at the beginning of this bulletin.

See the *Manual for Graduate Students* for a detailed statement of procedure concerning graduation. Attendance at commencement exercises is expected, but permission to receive the degree in absentia may be granted by the Dean of the Graduate School.

All degrees conferred are tentative until final grade reports have been received and all requirements fulfilled, even though the student's name may have appeared in the commencement program.

DOCTORAL DEGREES

The Doctor of Philosophy, an academic degree, and the Doctor of Education, a professional degree, are conferred by the University. Recognized as different in purpose, the two programs consequently have different requirements in certain respects.

ADMISSION

A student who has been admitted to the Graduate School and has been accepted by the department or committee in charge of a major program in which the doctorate is offered may begin working toward a doctor's degree. However, he has no official status as a doctoral student and no assurance that he will be accepted as a doctoral candidate until he has passed a candidacy examination. This examination is administered by the major department or graduate program and is given early in the student's program.

GENERAL REQUIREMENTS

No specified number of courses completed or credits earned will assure attainment of the doctorate. The general requirements are based upon a period of residence, the writing of a satisfactory thesis, and the passing of a comprehensive and a final oral examination. A doctoral program consists of such a combination of courses, seminars, and individual study and research as meets the minimum requirements of the Graduate School and is approved by the doctoral committee for each individual student.

A master's degree is not a prerequisite for the doctorate in some major programs. However, the first year of graduate study leading to the Ph.D. may be substantially the same as that provided for the M.A. or M.S. degree. Similarly the first year of the D.Ed. program may be essentially the same as that provided for the M.Ed.

GRADE-POINT AVERAGE

A minimum grade-point average of 3.00 for work done at the University is required for admission to the comprehensive examination and for graduation in the case of all candidates whose first registration for graduate study at the University occurred in the spring term 1964 or later.

TIME LIMITATION

A student is required to complete his program within seven years from the date of his acceptance as a candidate.

OFF-CAMPUS AND TRANSFER CREDITS

Subject to the approval of his adviser and the head of his major department or program chairman, a student may register for research to be done away from the University Park Campus.

A maximum of 30 credits beyond the baccalaureate at an approved school not granting the doctorate in the student's major program may be accepted by the Graduate School in partial fulfillment of the requirements for a doctoral degree at The Pennsylvania State University. A maximum of two full academic years of work (60 credits) beyond the baccalaureate at a graduate school which grants the docorate in the candidate's major program may be accepted here to apply toward doctoral degree requirements. Academic work to be so transferred must meet the following criteria: (1) It must have been completed within five years prior to the date of admission to the Graduate School of The Pennsylvania State University, (2) it must appear on a graduate transcript, (3) it must be of at least "B" quality, and (4) it must be deemed applicable to the student's program by his current academic adviser, approved in writing, and submitted to the Graduate School Director of Admissions.

The following caveat should be noted. Pass-fail grades are not transferable to an advanced degree program unless the "pass" can be substantiated by the former institution as having at least "B" quality.

A completed master's degree may be transferred to a doctoral program with no intervening time limitation.

ADVISERS AND DOCTORAL COMMITTEES

After a student has been admitted to a degree program, he should confer with the head of his major department or program concerning procedures and the appointment of an adviser. Arrangement and approval of the details of the student's term-by-term schedule is the function of the adviser. This person may be a member of the doctoral committee or someone else designated by the head of the major program for this specific duty.

General guidance of a doctoral candidate is the responsibility of a doctoral committee consisting of four or more members of the Graduate Faculty. One member shall be from outside the candidate's major program. This committee is appointed by the Dean of the Graduate School, upon recommendation of the head of the major program, after the student is admitted to candidacy. At his discretion, the Dean may add other members to the committee. The supervisor of the candidate's thesis will usually, but not necessarily, be designated as chairman. The chairman must hold senior membership in the Graduate Faculty. An associate member may supervise the research for a doctoral candidate, and, with the approval of the Dean of the Graduate School, he may serve as chairman of a doctoral committee and thus may sign the title page of a thesis.

The doctoral committee is responsible for establishing the broad outline of the student's program and should review the program as soon as possible after his admission to candidacy. It will prepare, give, and evaluate the candidate's examinations, and supervise and approve his thesis. A favorable vote of at least two-thirds of the members of the committee is required for passing a comprehensive or a final oral examination. If a candidate fails an examination, it is the responsibility of the doctoral committee to determine whether he may take another examination.

The committee will also notify the Dean when the candidate is ready to have his comprehensive and his final oral examination scheduled and will report the results of these examinations to the Dean.

COMMUNICATION AND FOREIGN LANGUAGE COMPETENCE

A candidate for the degree of Doctor of Philosophy is required to demonstrate high-level competence in the use of the English language, including reading, writing, listening, and speaking. Proficiency is expected at the time of admission to the Graduate School or must be achieved before admission to candidacy.

In addition to demonstrating competence in English, each candidate for the Ph.D. must meet any communication and foreign language requirements which have been established by his major program.

If a candidate is to be examined for a reading knowledge of a foreign language other than French or Spanish, he must report his intention to take the examination to the secretary of the language department by the end of the first week of classes for the term during which he wishes to take it. This date is one week prior to the examination date. The examination will be administered on dates announced in the Graduate Calendar at the beginning of this bulletin.

If a student is to be examined in French or Spanish, he must make application for the Graduate School Foreign Language Tests through the Educational Testing Service at Princeton. N. J., by returning a completed registration form to Princeton prior to the registration dates listed in the Graduate Calendar. All dates refer to the date of receipt at ETS. The Pennsylvania State University has been named as a testing center for the administration of the written tests. Registration materials are obtainable from the Graduate School reception office, 205 Kern Graduate Building, or the student may write directly to Educational Testing Service.

Each candidate must submit the proper fee of $10 per test with his registration form. A penalty fee of $3.50 is assessed for registrations received at ETS one week after the publicized registration date.

Candidates for the Doctor of Education degree may be required to demonstrate competency in foreign languages.

CANDIDACY EXAMINATION

This examination is administered by the Graduate Faculty in the major graduate program and should be taken early in the student's program. The nature of the examination varies with the program and may be the master's examination if so allowed. The decision to admit a student to candidacy or to reject him must be made by Graduate Faculty or a designated committee of Graduate Faculty. For the Ph.D. student following the new requirements, the examination may be given after he has earned at least 12 credits in graduate courses beyond the baccalaureate. He must take the examination not later than three terms in which he has registered after earning 24 credits.

For all other Ph.D. and D.Ed. students, the examination should be given when the student has earned a total of approximately 30 credits, including his master's program and work done elsewhere. A student transferring from another graduate school with 30 or more transfer credits must be given the candidacy examination before he has earned more than 10 credits here.

COMPREHENSIVE EXAMINATION

When a candidate for the Ph.D. or D.Ed. degree has substantially completed his course work, he is required to take a comprehensive examination covering his major program and minor field of study.

A candidate for the Ph.D. must have satisfied the communication and foreign language requirement before taking the examination.

All candidates whose first registration for graduate study at the University occurred in the spring term 1964 or later are required to have a minimum grade-point average of 3.00 for work done at the University at the time the comprehensive examination is given.

The examination is officially scheduled and announced by the Dean of the Graduate School upon recommendation of the doctoral committee. It is given and evaluated by the doctoral committee and may be *either written or oral, or both.* A favorable vote of at least two-thirds of the members of the committee is required for passing. In case of failure it is the responsibility of the doctoral committee to determine whether the candidate may take another examination. The results are reported to the Dean of the Graduate School, and will be entered on the candidate's official record.

When a period of more than five years has elapsed between the passing of the comprehensive examination and the completion of his program, the student is required to pass a second comprehensive examination before the final oral examination will be scheduled.

FINAL ORAL EXAMINATION

The doctoral candidate who has satisfied all other requirements for the degree will be scheduled by the Dean of the Graduate School, on recommendation of the doctoral committee, to take a final examination. Normally the final oral examination may not be scheduled until at least three months have elapsed after the comprehensive examination was passed, although the Graduate Dean may grant a waiver in the case of an outstanding student. The deadline for holding the examination is seven weeks before commencement.

The final examination is oral, open to the public, and related in large part to the thesis; but it may cover the candidate's whole program of study without regard to courses that have been taken either here or elsewhere.

A favorable vote of at least two-thirds of the members of the committee is required for passing. The results of the examination are reported to the Dean of the Graduate School and will be entered upon the candidate's official record. If a candidate fails, it is the responsibility of the doctoral committee to determine whether he may take another examination.

Ph.D. — ADDITIONAL SPECIFIC REQUIREMENTS

The degree of Doctor of Philosophy is conferred in recognition of high attainment and productive scholarship in some special field of learning as evidenced by (1) the satisfactory completion of a prescribed period of study and investigation, (2) the preparation of a thesis involving independent research, and (3) the successful passing of examinations covering both the special subject and the general field of learning of which this subject forms a part.

In the fall term 1967 a revised set of requirements for the Ph.D. went into effect. A student who, by the end of the summer term 1967, had earned 45 or fewer graduate credits which were applicable toward his degree follows the new requirements.

RESIDENCE REQUIREMENTS

There is no required minimum of credits or terms of study, but over some twelve-month period during the interval between admission to candidacy and completion of the Ph.D. program the candidate must spend at least three terms (which may include the term in which the candidacy examination is taken) as a registered student, during which time he is engaged in full-time academic work on the University Park Campus or at The Milton S. Hershey Medical Center *and* is certified by his department as devoting half time or more to graduate studies and/or thesis research to meet his degree requirements.

After a student has passed the comprehensive examination and met the three-term residence requirement, no further registration for credit will be required by the Graduate School. He shall, however, maintain his status as a student by registering continuously (at least three terms per calendar year) until the thesis is accepted by his doctoral committee. This registration may be for (1) noncredit 601 or 611 *only* for which he pays the dissertation fee, (2) noncredit 601 or 611 for which he pays the dissertation fee plus course registration at the regular per credit fee, and (3) full-time course credits for which he pays the regular tuition fee. Grades are not given for noncredit 601 or 611.

OLD RESIDENCE REQUIREMENTS

A student who had earned more than 45 credits by the end of the summer term 1967 will be required to span a minimum of nine terms in full-time graduate study and research (10 credits per term), or their equivalent in credits (90 credits), for the Ph.D. At least 30 credits must be earned in residence at the University Park Campus.

For a period of three terms, two of which must be consecutive, the Ph.D. candidate must limit his work load to half-time at most, the balance of his time being devoted to graduate study.

A graduate assistant or research assistant who is a candidate for the doctorate, has passed the comprehensive examination, is registered for the maximum allowable credit load, and is certified by his department as devoting all his time to studies and thesis research to meet his degree requirements may be regarded by the Dean of the Graduate School as a full-time student for a period not exceeding one calendar year. Such a student will be considered to earn the equivalent of 10 credits per term, and three such terms will meet the minimum residence requirement for the Ph.D.

MINOR FIELD

A Ph.D. candidate is not required by the Graduate Faculty to have a minor field of study. However, a department or a committee in charge of a major field may require a candidate to offer work in a minor field, or a student may elect such a program with the permission of his doctoral committee.

A minor consists of no fewer than 15 credits, including those applied toward the master's degree, of integrated or articulated work in one field related to, but different from, that of the major. A minor program must meet the approval of the departments or committees responsible for both the major program and the minor field.

THESIS

The ability to do independent research and competence in scholarly exposition must be demonstrated by the preparation of a thesis on some topic related to the major subject. It should represent a significant contribution to knowledge, be presented in a scholarly manner, reveal an ability on the part of the candidate to do independent research of high quality, and indicate considerable experience in using a variety of research techniques. The contents and conclusions of the thesis must be defended at the time of the final oral examination.

The completed thesis, together with two copies of an abstract, must be filed in the Office of Theses and Publications not later than five weeks prior to the commencement at which the candidate expects to receive the degree.

A *Thesis Information Bulletin,* which gives details concerning format, paper, illustrations, and other items, may be obtained at the Graduate School Office of Theses and Publications, 320 Kern Graduate Building.

D.Ed. — ADDITIONAL SPECIFIC REQUIREMENTS

Programs leading to the degree of Doctor of Education are not limited to specific fields of education but, with the consent of the department or committee in charge and concurrence by the dean of the college, may also be offered in any other field appropriate to the preparation of teachers which has been approved for the doctorate.

The degree is conferred in recognition of advanced preparation of a high order for work in the profession of education as evidenced by (1) satisfactory completion of a prescribed period of study; (2) ability to apply scientific principles in classroom instruction, supervision of instruction, administration, or as a consulting specialist in certain educational areas; (3) preparation of a thesis demonstrating ability to undertake an educational problem with originality and independent thought; and (4) successfully passing examinations, i.e., showing a satisfactory grasp of the field of specialization and its relation to allied educational areas.

RESIDENCE REQUIREMENTS

A minimum of nine terms of full-time graduate study and research (10 credits per term), or their equivalent in credits (90 credits), of which at least 30 credits must be earned in residence, is required for the D.Ed. degree. The D.Ed. candidate may meet the requirements by attending summer terms unless his major department requires a period of registration in other terms or in consecutive terms at University Park. A candidate may register for a maximum of 30 credits of research in absentia, but none of these may count toward the minimum of 30 credits which he is required to earn on the University Park Campus. It is expected that students will register for a minimum of 15 credits of thesis research. The maximum credit load permitted a student who is employed full-time is 4 credits per term.

MAJOR PROGRAM AND MINOR FIELD

The program of study includes a major and either a minor or a group of general studies. A majority of the courses offered in fulfillment of the requirements must be in the major program of study.

A candidate choosing a major outside the field of education (such as speech, geography, or history) shall have a minor consisting of no fewer than 15 credits in education, including those applied toward the master's degree, as approved early in his program by a faculty adviser designated by the College of Education.

A candidate choosing a major in one of the major programs in education must also choose either a minor or a group of general studies with the approval of the major program chairman. In this case a minor consists of no fewer than 15 credits, including those applied toward the master's degree, in one field outside those of education. An acceptable general studies group consists of no fewer than 15 credits, including those applied toward the master's degree, in fields outside those of education considered by the major program committee to have significance and value for the candidate.

COMPREHENSIVE EXAMINATION

In addition to demonstrating a high level of competence in the subject matter of his major program and minor field, each candidate must show in his comprehensive examination that he is familiar with current theories of education; that he understands and can apply the techniques and the findings of educational research so far as they bear upon the teaching of his subject; that he is prepared to read understandingly and contribute to the technical and professional literature in his field; and that he can criticize his own procedures in the light of historical trends and practices in this and other countries. Command of the tools for a thorough study of the problems of education is necessary and must include familiarity with statistical methods. For certain students the requirements may include a reading knowledge of one or more foreign languages.

All candidates whose first registration for graduate study at the University occurred in the spring term 1964 or later are required to have a minimum grade-point average of 3.00, for work done at the University, at the time the comprehensive examination is given.

THESIS

Evidence of a high degree of scholarship, competence in scholarly exposition, and ability to select, organize, and apply knowledge must be presented by the candidate in the form of a written thesis. The candidate must demonstrate a capacity for independent thought as well as ability and originality in the application of educational principles or in the development of new generalizations under scientific controls. A thesis may be based upon a product or project of a professional nature, provided scholarly research is involved. For example, it may be based upon the solution of a professional problem concerned with the development of a curriculum, or a product of creative effort related to education. However, in order to be acceptable as a thesis, the professional project must be accompanied by a written discourse demonstrating the nature of the research and including such theories, experiments, and other rational processes

as were used in effecting the final result. The topic and outline of the proposed thesis must have the approval of the doctoral committee.

The completed thesis, together with two copies of an abstract, must be filed in the Office of Theses and Publications not later than five weeks prior to the commencement at which the candidate expects to receive the degree.

A *Thesis Information Bulletin,* which gives details concerning format, paper, illustrations, and other items, may be obtained at the Graduate School Office of Theses and Publications, 320 Kern Graduate Building.

MASTER'S DEGREES

The Graduate School recognizes a difference in purpose, which is reflected in the requirements, for two types of advanced degrees, academic and professional. Of the thirteen master's degrees conferred, the Master of Arts and the Master of Science are academic in nature. The professional degrees conferred are Master of Administration, Master of Agriculture, Master of Business Administration, Master of Education, Master of Engineering, Master of Environmental Pollution Control, Master of Fine Arts, Master of Forestry, Master of Nursing, Master of Public Administration, and Master of Regional Planning.

A degree is not conferred for a mere collection of credits. A well-balanced, unified, and complete program of study will be required, which may frequently exceed the minimum requirement specified below.

A student may meet the degree requirements by either full-time or part-time enrollment and by attendance in any combination of terms. The student who interrupts the continuity of his registration faces the possibility of not being granted permission to return.

GRADE-POINT AVERAGE

A minimum grade-point average of 3.00 for work done at the University is required for graduation in the case of all candidates whose first registration for graduate study at the University occurred in the spring term 1964 or later.

TIME LIMITATION

All requirements for a master's degree, whether satisfied on the University Park Campus or elsewhere, must be met within six years or a period spanning seven consecutive summers.

ADMISSION

In addition to the general University requirements for admission set forth at the beginning of this bulletin, adequate undergraduate preparation is required in the program in which the applicant expects to pursue advanced work. The specific courses and the total number of undergraduate credits required in various areas will be determined by the choice of program and can be ascertained from the descriptive statement appearing under the major program heading in the latter portion of this bulletin. An applicant who meets the necessary grade-point average but is deficient in course preparation may, under certain circumstances, be admitted to the Graduate School and allowed to make up the undergraduate deficiencies. Under these circumstances the program will require more than the necessary period of residence. An applicant for admission to the M.Ed. program in most major programs is required to have had at least 18 credits in education and related psychology, and in certain major programs may be required to have had practice teaching.

After a student has been admitted to a degree program, he should confer with the head of his major department or program concerning the appointment of an adviser. The general guidance of a master's candidate is the responsibility of an adviser, or of a committee appointed in a manner to be determined by the major department or program in which the student is specializing. The adviser or the committee assists the student in planning a program of study.

Although the adviser is frequently the supervisor of the thesis, this is not necessarily the case.

Requirements concerning courses, language proficiency, minors, comprehensive examinations, and other matters are sometimes made by departments or programs in addition to (but not in conflict with) the regulations of the Graduate School. For details the student should consult the head of the major department or program.

TRANSFER CREDIT

Subject to the limitations given below on the use of credits earned at other accredited institutions, a maximum of 10 credits of high quality graduate work done at another institution may be applied toward a master's degree here.

The student should distinguish carefully between the transferability of credit and its applicability in a particular degree program as approved in writing to the Graduate School Director of Admissions by his academic adviser. Such academic work transferred must have been completed within five years prior to the date of admission to the Graduate School of The Pennsylvania State University, must be of at least "B" quality, and must appear on a graduate transcript.

Pass-fail grades are not transferable to an advanced degree program unless the "pass" can be substantiated by the former institution as having at least "B" quality.

Forms for transfer of credit may be obtained from the Office of Graduate Admissions, 310 Kern Graduate Building.

EXAMINATIONS

A candidate may be required to pass in a satisfactory manner such written or oral examinations as his program head may designate. A candidate should consult his major department for such special requirements.

Examinations to establish credit for work done *in absentia* or without formal class work may be used to remove undergraduate deficiencies, but *not* to earn credits toward an advanced degree. Arrangements are made by the student directly with his major department or program.

Graduate Record Examinations are designed to test information and abilities in basic fields of knowledge. Provisions are made on the campus for administering these examinations at scheduled times and upon request of students or department program chairmen. Informational materials may be obtained in 205 Kern Graduate Building.

ENGLISH PROFICIENCY OF FOREIGN STUDENTS

Entering graduate students from countries other than the United States are required to demonstrate high-level competence in the use of the English language, including reading, writing, speaking, and listening. Upon arrival at the University, such students are requested to report to the International Center, 111 Kern Graduate Building, where an appointment for the English language proficiency interview will be made. Students with an obviously good command of English will be exempted from formal testing; others will be scheduled for a series of proficiency tests. The Graduate School at The Pennsylvania State University requires all foreign graduate students who are working toward a degree to pass an English language examination. Remedial work will be prescribed as indicated by the tests.

Before a foreign student can be accepted for enrollment at The Milton S. Hershey Medical Center and in many graduate major programs, a high-level competence in the use of the English language must be demonstrated by successful performance on the TOEFL (Test of English as a Foreign Language). Information on the time and place that this test is given in his geographical area can be obtained by writing to the Educational Testing Service, Box 592, Princeton, N.J. 08540.

M.A. and M.S. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Arts and the Master of Science degrees have similar requirements, the general major area determining which degree is conferred. Programs for both degrees are strongly oriented toward research.

A minimum of 30 graduate credits is required, of which at least 20 must be earned at an established graduate campus of the University. A minor is not required of all candidates for the M.A. or M.S. degree. A department or committee in charge of a major program may require a candidate to offer work in a minor field, or a student may elect such a program with the permission of his committee.

A minor consists of no fewer than 6 credits of integrated or articulated work in one field related to, but different from, that of the major. A minor program must meet the approval of the departments or committees responsible for both the major program and minor field.

The major department or the committee in charge of the major program is the judge as to the suitability of a field for the minor and of its relevance to the major. The minor field department has the responsibility of accepting or rejecting students, advising on courses to be taken by the candidate in the field, examining the candidate in the area of studies he has undertaken in the field, and certifying that the minor requirements have or have not been met.

At least 18 credits in the 500 and 600 series combined must be included in the program. A minimum of 12 credits in course week (400 and 500 series), as contrasted with research, must be completed in the major program. A thesis is required of many candidates for these degrees. Details are given in the introductory paragraphs under the major program headings in the latter part of this bulletin. If a student is required to write a thesis, at least 6 credits in thesis research (600 or 610) must be included in his program. If no thesis is required, at least 18 credits must be in 500 courses.

Those candidates who are not required to write a thesis must present a suitable essay or paper. Its nature and extent shall be determined by the major program. The department head or program chairman shall report to the Dean of the Graduate School the title, the name of the faculty member under whom the student did the work, and whether the work was considered adequate. The program head may require one or more copies of such an essay for its library or other files.

A thesis is prepared under the direction of the department or program in which the candidate's major work is taken. Under certain conditions a student may complete the thesis off campus. To do so he must make satisfactory arrangements in advance with his adviser and the head of his major department or program.

Requirements for the M.A. degree at the Capitol Campus differ somewhat from the above and are outlined under the major programs in American studies and humanities. These programs are available only at the Capitol Campus.

A *Thesis Information Bulletin,* which gives details concerning format, paper, illustrations, and other items, may be obtained at the Graduate School Office of Theses and Publications, 320 Kern Graduate Building.

M.Adm. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Administration degree program is intended to meet the professional needs of practicing and potential administrators in the fields of business, engineering, government, health, and social service. All students must satisfy preparatory requirements for their particular program and complete at least 30 credits of graduate courses, with the majority of the courses at the 500 level. Three options are offered:

(1) the business administration option is intended for students who desire to pursue an administrative career in business, industry, or institutions, (2) the engineering administration option prepares individuals for management positions in engineering, scientific, and technical organizations, and (3) the public administration option prepares individuals for administrative responsibility in local, state, or federal government, institutions, and social service agencies.

Each student is required to complete a professional paper of the quality, if not the theoretical depth, of a thesis and it must be defended before a committee of Graduate Faculty members. The candidate will be expected to demonstrate his ability to integrate knowledge of a specialized area with a broad understanding of the general field of administration.

The program is offered only at the Capitol Campus.

M.Agr. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Agriculture is a professional degree. Thus, programs leading to this degree provide opportunities for students to increase their knowledge and competences in the various phases of agriculture. A student, according to his needs, may obtain (1) intensive training encompassing a wide spectrum of subject matter area or (2) intensive training in a specialized area. The emphasis of the program is to enable students to develop skill as professional practitioners in the communication of technical knowledge and its application to the solution of current and future technical, economic, and social problems of individuals and groups.

The head of the department or program chairman shall appoint a three-member committee to guide and monitor the candidate's professional development. Members of this committee must represent at least two departments. The chairman of the appointed committee shall serve as the candidate's adviser. Early in his program, the candidate will inform the committee of his background and aspirations. The committee will suggest to the student how best to achieve these goals and the standard of professional competence required for the Master of Agriculture degree.

A minimum of 30 graduate credits is required of which 20 credits must be earned in residence at the University Park Campus. A maximum of 10 credits may be earned in special problem type courses.

The candidate must present an acceptable paper on a selected professional problem or a report of internship training. Up to 3 graduate credits will be given for an acceptable paper. The candidate may be required to provide one or more copies of the paper for the University.

The candidate's committee shall report through the department head or program chairman to the Dean of the Graduate School the title of the paper and whether the paper and the candidate's academic performance were considered satisfactory.

M.B.A. — ADDITIONAL SPECIFIC REQUIREMENTS

The purpose of the Master of Business Administration degree program is to develop professional managerial knowledge and skills as these are applied to the decisions in business enterprises. Teaching focuses upon the techniques, the theory, and the skills important to modern administrators.

At least 36 graduate credits are required of which 18 or more are to be completed at the 500 level and 26 hours at University Park. Candidates who are admitted without an undergraduate business background may be required to undertake up to 30 hours of work preparatory to full status as an M.B.A candidate. During the later stages of course work, some specializations within a major area of student interest and an M.B.A project paper are undertaken. Applications must include the results of the Admission Test for Graduate Study in Business sent directly from the Educational Testing Service.

M.Ed. — ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Education provide preparation for increased professional competence in the areas of education and teaching. They should be distinguished

carefully from the research-oriented programs which lead to the academic degree of Master of Arts or Master of Science. In most major programs the requirements for admission include 18 credits in education and related psychology.

A minimum of 30 graduate credits is required for the degree, of which at least 20 must be earned at an established graduate campus of the University; at least 24 must be in course work. This degree is offered also at the Capitol Campus and the King of Prussia Graduate Center.

MAJOR PROGRAMS IN THE FIELDS OF EDUCATION

A student may major in one of the approved programs in education, such as art education, educational psychology, or home economics education, and proceed under the guidance of the appropriate major in education.

A program of this type requires at least 6 credits to be earned outside the programs in education.

MAJOR PROGRAMS OUTSIDE THE FIELDS OF EDUCATION

A student who is preparing to teach in a specific subject-matter field, such as geography, mathematics, or German, may choose such a program as his major and take the majority of his work in it under the guidance of the department offering that major. A student wishing to work in a broader area may choose a major such as biological science, earth sciences, physical science, or social studies and take at least 24 credits in the area under the guidance of the committee in charge of the major.

Each candidate is required to earn 6 credits in education as directed by the faculty of one of the approved graduate programs in education. The 6 credits may be taken in educational foundations, which includes courses in comparative education; history, sociology, and philosophy of education; and educational psychology.

THESIS OR PAPER

Six credits may be granted for an approved thesis. A candidate who does not elect to write a thesis is required to present an essay or paper. It must be of considerable proportion, indicating capacity to describe a serious intellectual experience adequately in writing, and giving unmistakable evidence of ability to formulate and state meaningfully the purpose of an investigation, study, critical analysis, or evaluation; to acquire and analyze information; to draw conclusions logically; and to relate findings to professional problems and practices. The nature and extent of such a piece of writing, whether it be required in connection with a course or independently of course work, and when it is to be undertaken shall be determined by the major program. The department head or program chairman shall report to the Dean of the Graduate School the title, the name of the faculty member under whom the student did the work, and whether the work was considered adequate. It is the right, but not the responsibility, of the department head or program chairman to require one or more copies of such an essay for its library or other files.

M.Eng. — ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Engineering provide training for advanced professional competence in the several fields of engineering. They should be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Science.

A minimum of 30 graduate credits is required of which 20 must be earned at an established graduate campus of the University. At least 12 credits must be earned in graduate courses (500 series).

A scholarly written report on a developmental study involving at least one area represented in the candidate's course work is required as an integral part of the program. The report must

be comparable in its level of work and quality to a graduate thesis. The topic of the developmental study is subject to prior approval by the department in which the candidate's major work is taken, and preparation of the written report shall be under the direction of that department.

No work for this degree is required to be done specifically on the University Park Campus provided the major department or supervisory committee and the Dean of the Graduate School agree that a complete program of study can be pursued at the Capitol Campus or at the Behrend or King of Prussia Graduate Centers of The Pennsylvania State University.

M.E.P.C. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Environmental Pollution Control is an intercollege professional degree designed for students who are interested in pursuing a career in the field of environmental pollution control. Special requirements include 9 credits of core courses covering air and water pollution control and solid waste management and participation in the environmental pollution control seminar program. A minimum of 30 graduate credits are required of which at least 9 must be at the 500 level and 20 must be taken at the University Park Campus. A thesis will be optional. If a thesis is written, at least 6 credits of thesis research (600 or 610) must be taken.

M.F.A. — ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Fine Arts provide training for increased professional competence in the several specialized areas of the arts. They should be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Arts with a major in art, music, or theatre arts.

A minimum of 48 credits is required, of which at least 38 must be earned on the University Park Campus. The larger part of these credits should be above the 400 level, but the needs of the student shall be considered in arranging the best combination of courses and research for the preparation of the candidate in his particular field.

A professional project, either creative or interpretative, is required. This project shall include a monograph in support of the creative or interpretative aspect; such monograph shall represent a minimum of 6 credits on the 600 level.

M.F. — ADDITIONAL SPECIFIC REQUIREMENTS

The program leading to the degree of Master of Forestry provides training for increased professional competence in the several specialized areas of forest resource management and forest products. It should be distinguished carefully from the research-oriented program which leads to the academic degree of Master of Science with a major in forest resources.

A minimum of 30 graduate credits is required, of which at least 20 must be earned on the University Park Campus.

A candidate for the degree of Master of Forestry should choose one area for his major and one or two related areas for his minor. The proportion of credits to be taken in the major and minor fields of study will be determined in consultation with the student's advisory committee. It is expected that the larger part of the program shall be in graduate courses (500 series), but no specific number of credits in the 500 series is required.

Each candidate is required to submit an acceptable thesis based on at least 6 credits of thesis research.

M.N. — ADDITIONAL SPECIFIC REQUIREMENTS

The purpose of the Master of Nursing degree program is to develop specialized skills in nursing. The program focuses on safety, efficiency, patient assessment (physical and psychosocial), and patient welfare and satisfaction. Besides the scientific principles guiding nursing practice, students examine the moral, ethical, and legal aspects of health care, with freedom to explore creative solutions to management problems.

A minimum of 30 credits is required, with at least 20 to be earned on the University Park Campus. At least 10 of these credits must be earned in nursing practicum courses. Other off-campus sites may be used for selected practicums. Each student must present an acceptable clinical paper and pass a comprehensive examination.

M.P.A. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Public Administration is a professional degree for students who are planning careers in public administration in local, state, and national governmental jurisdictions, or in international, private, or voluntary agencies. This program should be distinguished from the research-oriented program which leads to the academic degree of Master of Arts with a major in political science in which the candidate may specialize in public administration.

For the M.P.A. degree a minimum of 30 graduate credits is required of which 20 must be earned at an established graduate campus of the University. The greater portion of the courses must be at the 500 level. An M.P.A. essay or paper will also be required but will carry no graduate credit. A comprehensive final examination will be given to all candidates.

The M.P.A. degree offered at the Capitol Campus at Middletown requires a minimum of 30 graduate credits including a professional master's paper. There is no comprehensive final examination, but an oral defense of the master's paper is required.

The degree is a terminal one, and credits earned in the program may or may not be applicable, even in part, toward a doctorate.

M.R.P. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Regional Planning is a professional degree for students interested in a coordinated attack on the problems of community development and resource management. The program is intended to acquaint the student with rational programs of spatial allocation of land uses and facilities, maintenance of cultural and aesthetic values, and legal and governmental techniques for their implementation.

A minimum of 45 graduate credits is required of which 35 must be earned at an established graduate campus of the University. A minimum of 36 credits is required in planning courses, at least 6 of which will be earned in preparing (1) a problem-oriented thesis, or (2) an individual project report, comparable in quality and scope to a graduate thesis, or (3) a project written in a terminal integrative course in regional planning.

This degree is also offered at the Capitol Campus.

GRADUATE MAJOR PROGRAMS OF STUDY

The following degrees are the ones normally conferred in each of the designated major programs. Additional professional degrees, including the M.Agr., M.Ed., and M.Eng., have been authorized in many cases and may be offered at the discretion of the department head or program chairman and the Dean of the Graduate School. Thus, the M.Ed. had been authorized for all of the above programs in which a master's degree is conferred provided the program is appropriate to the preparation of teachers.

Administration (Capitol) — M.Adm.
Aerospace Engineering — Ph.D., M.S.
Agricultural Economics — Ph.D., M.S., M.Agr.
Agricultural Education — Ph.D., D.Ed., M.S., M.Ed.
Agricultural Engineering — Ph.D., M.S.
Agronomy — Ph.D., M.S., M.Agr.
American Studies (Capitol) — M.A.
Anatomy (Hershey) — Ph.D., M.S.
Animal Industry — Ph.D., M.S., M.Agr.
Animal Nutrition — Ph.D., M.S.
Anthropology — Ph.D., M.A.
Architectural Engineering — M.S.
Architecture — M.S.
Art — M.A., M.F.A.
Art Education — Ph.D., D.Ed., M.S., M.Ed.
Art History — Ph.D., M.A.
Astronomy — Ph.D., M.S.
Biochemistry — Ph.D., M.S.
Bioengineering — Ph.D., M.S.
Biological Chemistry (Hershey) — Ph.D., M.S.
Biological Science — D.Ed., M.Ed.
Biology — Ph.D., M.S.
Biophysics — Ph.D., M.S.
Botany — Ph.D., M.S.
Business Administration — Ph.D., M.S., M.B.A.
Ceramic Science — Ph.D., M.S.
Chemical Engineering — Ph.D., M.S., M.Eng.
Chemistry — Ph.D., M.S.
Civil Engineering — Ph.D., M.S., M.Eng.
Classics — M.A.
Community Systems Planning and Development — Ph.D., M.S.
Comparative Literature — Ph.D., M.A.
Computer Science — Ph.D., M.S.
Counselor Education — Ph.D., D.Ed., M.S., M.Ed.
Dairy Science — Ph.D., M.S.
Developmental and Remedial Reading — M.Ed.
Earth Sciences — D.Ed., M.Ed.
*Ecology — Ph.D., M.S.
Economics — Ph.D., M.A., M.Ed.
Education of Exceptional Children — Ph.D., D.Ed., M.S., M.Ed.
Educational Administration — Ph.D., D.Ed., M.S., M.Ed.
Educational Psychology — Ph.D., M.S.
Electrical Engineering — Ph.D., M.S.
Elementary Education — Ph.D., D.Ed., M.S., M.Ed., (Capitol, M.Ed.)
*Engineering Acoustics — Ph.D., M.S., M.Eng.
Engineering Mechanics — Ph.D., M.S., M.Eng.
Engineering Science (Behrend, King of Prussia, Capitol) — M.Eng.
English — Ph.D., D.Ed., M.A., M.Ed.
Entomology — Ph.D., M.S., M.Agr.
*Environmental Pollution Control — M.S., M.Eng., M.E.P.C.
*Extension Education — M.Agr., M.Ed.
Food Science — Ph.D., M.S.
Forest Resources — Ph.D., M.S., M.F.
French — Ph.D., M.A.
Fuel Science — Ph.D., M.S.
General Engineering — M.Ed., M.Eng.
*Genetics — Ph.D., M.S.
Geochemistry — Ph.D., M.S.
Geography — Ph.D., D.Ed., M.S., M.Ed.
Geology — Ph.D., M.S.
Geophysics — Ph.D., M.S.
German — Ph.D., M.A., M.Ed.
Higher Education — D.Ed., M.Ed.
History — Ph.D., D.Ed., M.A., M.Ed.
Home Economics Education — D.Ed., M.S., M.Ed.
Horticulture — Ph.D., M.S., M.Agr.
Human Development and Family Studies — Ph.D., D.Ed., M.S., M.Ed.
Humanities (Capitol) — M.A.
Industrial Arts Education — Ph.D., D.Ed., M.S., M.Ed.
Industrial Engineering — Ph.D., M.S., M.Eng. (King of Prussia, M.Eng.)
Journalism — M.A.
Laboratory Animal Medicine (Hershey) — M.S.

*Intercollege Graduate Programs

Linguistics — Ph.D., M.A.
Man-Environment Relations — Ph.D., D.Ed., M.S., M.Ed.
Mathematics — Ph.D., D.Ed., M.A., M.Ed.
Mathematics (King of Prussia) — M.Ed.
Mechanical Engineering — Ph.D., M.S., M.Eng.
Metallurgy — Ph.D., M.S.
Meteorology — Ph.D., M.S.
Microbiology — Ph.D., M.S.
Microbiology (Hershey) — Ph.D., M.S.
Mineral Economics — Ph.D., M.S.
Mineral Engineering Management — M.Eng.
Mineral Processing — Ph.D., M.S.
Mineralogy and Petrology — Ph.D., M.S.
Mining Engineering — Ph.D., M.S., M.Eng.
Music — M.A., M.F.A.
Music Education — D.Ed., M.Ed.
Nuclear Engineering — Ph.D., M.S., M.Eng.
Nursing — M.N., M.S.
Nutrition — Ph.D., D.Ed., M.S., M.Ed.
Nutrition in Public Health — M.S.
Petroleum and Natural Gas Engineering — Ph.D., M.S.
Pharmacology (Hershey) — Ph.D., M.S.
Philosophy — Ph.D., D.Ed., M.A., M.Ed.
Physical Education — Ph.D., D.Ed., M.S., M.Ed.
Physical Science — D.Ed., M.Ed.
Physics — Ph.D., D.Ed., M.S., M.Ed.
*Physiology (U.P., Hershey) — Ph.D., M.S.
Plant Pathology — Ph.D., M.S.
Political Science — Ph.D., M.A.
Poultry Science — Ph.D., M.S.
Psychology — Ph.D., M.S.
Public Administration — M.P.A.
Public Administration (Capitol) — M.P.A.
Recreation and Parks — M.S., M.Ed.
*Regional Planning (U.P., Capitol) — M.R.P.
Religious Studies — Ph.D., M.A.
Rural Sociology — Ph.D., M.S., M.Agr.
Sanitary Engineering — M.S., M.Eng.
*School Psychology — D.Ed., M.S., M.Ed.
Secondary Education — Ph.D., D.Ed., M.S., M.Ed.
Slavic Languages and Literatures — M.A.
Social Studies — M.Ed.
Sociology — Ph.D., M.A.
*Solid State Science — Ph.D., M.S.
Spanish — Ph.D., D.Ed., M.A., M.Ed.
Speech — Ph.D., D.Ed., M.A.
Speech Pathology and Audiology — Ph.D., D.Ed., M.S., M.Ed.
Statistics — Ph.D., M.S., M.A.
Theatre Arts — M.A., M.F.A.
Veterinary Science — Ph.D., M.S.
Vocational Industrial Education — Ph.D., D.Ed., M.S., M.Ed.
Wildlife Management — M.S.
Zoology — Ph.D., M.S.

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*Intercollege Graduate Programs

GRADUATE MAJOR PROGRAMS AND COURSES*

ADMINISTRATION (ADMIN)

F. FREDERICK NEUBAUER, *Chairman, Graduate Program in Administration at Capitol Campus*
Middletown, Pa. 17057

Degree Conferred: M.Adm.

Graduate Faculty: Senior Members Lee and Neubauer.
Graduate Faculty: Associate Members Brown, Gilmore, Murty, Poore, and Woodruff.

This program is intended to meet the professional needs of practicing and potential administrators. All students must satisy (1) a series of prerequisites for each option, (2) 15 credits of common core courses, and (3) at least 15 credits of option area course work. Options are currently available in Business Administration, Public Administration, and Engineering Administration. The Business Administration option is intended for those students who desire to pursue an administrative career in any phase of commerce, business, or industry. The Public Administration option is aimed at those students who desire to assume administrative responsibility in institutions, social work agencies, and local, state, or federal government. The Engineering Administration option is a quantitative program in management science and operations research.

The prerequisite requirements are an integral part of the program. Some or all of these requirements may be waived, based on equivalent work previously completed.

For Business Administration, prerequisite courses are required in micro- and macroeconomic analysis, advanced economic analysis (Econ. 405), finite mathematics, calculus, probability and statistics, accounting, finance, marketing, management, quantitative models, introduction to computer, and business law.

For Public Administration, prerequisite courses are required in micro- and macroeconomic analysis, finite mathematics, probability and statistics, accounting, introduction to computer, and adequate preparation in the social sciences.

For Engineering Administration, prerequisite courses are required in micro- and macroeconomic analysis, advanced economic analysis (Econ. 405), finite mathematics, calculus, differential equations, quantitative models, linear algebra, probability and statistics, introduction to computer, accounting and finance, and graduation from an accredited undergraduate curriculum in engineering, mathematics, or physics.

For admission to the Master of Administration program, the student must have a baccalaureate degree from an accredited institution. Students with a 2.75 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.75 grade-point average may be made for students with special backgrounds, abilities, and interests.

Applicants for Business and Engineering Administration are required to take the Admission Test for Graduate Study in Business. Applicants for Public Administration are required to take the Aptitude Test of the Graduate Record Examination.

The program is offered only at the Capitol Campus.

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*A course abbreviation, a number, and a title designate each course. Course designations and official abbreviations are listed in the left-hand margin just above the first course in each group. The figures in parentheses following the course title show the number of credits which may be granted for that course. In the case of courses with variable credits, the number of credits which may be earned in a single term is determined by the department or program offering the course.

A department or major program may schedule an entire section of a course below the 400 level for fewer credits than the maximum authorized. In 400- and 500-series courses an individual student may schedule fewer credits than the minimum number but in no case more than the maximum number authorized.

All courses listed under graduate major programs may not be required in the particular major.

COURSES*

ECON. 404. CURRENT ECONOMIC ISSUES (3)
ECON. 405. ADVANCED ECONOMIC ANALYSIS (3)
ECON. 419. CASE STUDIES IN LABOR-MANAGEMENT RELATIONS (3)

ACCTG. 504. SEMINAR IN MANAGERIAL ACCOUNTING (3-6)

ACCTG. 511. FINANCIAL AND MANAGERIAL ACCOUNTING (3)

ADMIN. 500. ADMINISTRATIVE THEORY (3) History, significance and functions of administration, theories of leadership, authority, decision making, rationality, and efficiency.

ADMIN. 510. ORGANIZATION ANALYSIS (3) Examination of concepts of human behavior in formal organizations, systems analysis, conceptual models, and decision processes.

ADMIN. 520. ADMINISTRATIVE MODELS (3) Formulation and solution of decision models for administrative problems. Analysis of decision making under certainty, risk, and uncertainty.

ADMIN. 540. ADMINISTRATIVE POLICY FORMULATION (3) Analysis of administrative problems from a total organization viewpoint. Case studies of actual organizations are used for analysis.

ADMIN. 550. PROGRAM PLANNING AND EVALUATION (3) Analysis and evaluation of public programs and systems from the perspectives of policy development and administrative planning and management.

ADMIN. 551. ADMINISTRATION AND THE POLITICAL PROCESS (3) Analysis of the relationship of administration to the political processes that shape public policy formulation and execution.

ADMIN. 553-554. RESEARCH METHODS IN ADMINISTRATION (3 each) Examination of research methodologies relevant to public administration. Student independently develops and executes a significant research project. Prerequisites: Admin. 500, 551, and four option courses.

ADMIN. 560. SAMPLING THEORY AND PRACTICE (3) Study of scientific method of obtaining representative samples, collection of information, techniques of estimation. Prerequisite: Math. 315.

B.LOG. 538. LOGISTICS SYSTEMS MANAGEMENT (3)

FIN. 531. FINANCIAL MANAGEMENT (3)

I.B. 501. THE INTERNATIONAL ENVIRONMENT (3)

I.E. 508. OPERATIONS RESEARCH I (3)

I.E. 509. OPERATIONS RESEARCH II (3)

I.E. 510. MATHEMATICAL PROGRAMMING (3)

MGMT. 510. OPERATIONS MANAGEMENT (3)

MGMT. 540. PERSONNEL MANAGEMENT (3)

MKTG. 500. MARKETING MANAGEMENT (3)

MKTG. 530. CONSUMER AND MARKET BEHAVIOR (3)

PL.SC. 575. GOVERNMENT MANPOWER MANAGEMENT (3)

PL.SC. 576. GOVERNMENT FISCAL DECISION MAKING (3)

Q.B.A. 501. ADVANCED BUSINESS STATISTICS (3)

Q.B.A. 570. MANAGEMENT SCIENCE: IMPLEMENTATION AND CONTROL (3)

*Course descriptions not given below will be found under the designated field of study.

AEROSPACE ENGINEERING (AERSP)

BARNES W. MCCORMICK, *Head of the Department*
233 Hammond Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Arndt, Holl, Lakshminarayana, Lancaster, Lumley, Kaplan, McCormick, and Tennekes.
Graduate Faculty: Associate Members Allen, Eisenhuth, Phillips, and York.

Opportunities are available for graduate study in the following areas: low-speed aerodynamics, V/STOL aircraft, turbulence, geophysical fluid dynamics, astrodynamics, turbomachinery, plasma dynamics, rarefied gas dynamics, hydrodynamics, stability and control of aerospace vehicles, aeroelasticity, and aerospace structures.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by an intermediate knowledge of two foreign languages, by substitution of courses from other designated areas for one of these languages, or by a comprehensive knowledge of one foreign language.

The entering student must hold a bachelor's degree in physical science, mathematics, or engineering and may be required to complete (without degree credit) undergraduate course work in fluid and solid mechanics and intermediate mathematical analysis, if he has not already done so. Students with a 2.70 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.70 grade-point average may be made for students with special backgrounds, abilities, and interests.

AEROSPACE ENGINEERING (AERSP)

401a,b,c. AEROSPACE ENGINEERING PROJECTS (1-12)
405. EXPERIMENTAL METHODS IN AEROSPACE ENGINEERING (3)
407. AERODYNAMICS OF V/STOL AIRCRAFT (3)
409. ADVANCED AEROSPACE STRUCTURAL MECHANICS (3)
410. AEROSPACE PROPULSION (3)
411. AEROELASTICITY (3)
412. TURBULENT FLOW (3)
413. STABILITY AND CONTROL OF AIRCRAFT AND MISSILES (3)
415. PHYSICAL GAS DYNAMICS (3-6)
416-417. AEROSPACE DESIGN AND THESIS (2 each)
420. PRINCIPLES OF FLIGHT TESTING (3)
421. (M.E. 421) INTERMEDIATE VISCOUS FLOW (3)
425. THEORY OF FLIGHT (3)
430. SPACE PROPULSION AND POWER SYSTEMS (3)
444. NOISE POLLUTION OF FLUID DYNAMIC ORIGIN (3)
450. ORBIT AND ATTITUDE CONTROL OF SPACECRAFT (3)

503. ELECTROMAGNETICALLY AND CHEMICALLY ACTIVE FLOWS (3) Flow of media which may be conductive, permeable, ionizable, or otherwise capable of interacting with imposed or self-generated fields.

504. AERODYNAMICS OF V/STOL AIRCRAFT (3) Jet wings, high lift devices, propellers and ducted propellers, circulation and boundary layer control, unsteady airfoil theory. Prerequisite: Aersp. 407.

505. AERO- AND HYDROELASTICITY (3) Interaction of elastic systems having several degrees of freedom with fluid flows in various configurations.

506. CAVITATION (3) Flow regimes, dynamics of cavitation, prediction of the minimum pressure in the fluid, scale effects, effect of surface irregularities.

507. THEORY AND DESIGN OF TURBOMACHINERY (3) Theory and principles of machinery design: compressors, turbines, pumps, and rotating propulsors; opportunity to work out design examples.

508. FOUNDATIONS OF FLUID MECHANICS (3) Mathematical review, fluid properties, kinematics, conservation laws, constitutive relations, similarity principles, the boundary layer, inviscid flow, vorticity dynamics, wave motion.

509. DYNAMICS OF IDEAL FLUIDS (3) Irrotational flow theory, two-dimensional and axisymmetric flows, airfoil theory, complex variables, unsteady phenomena; flow with vorticity, finite wing theory. Prerequisite: Aersp. 508.

510. COMPRESSIBLE FLOW (3) Classification and solution of compressible flow problems, high speed gasdynamics, unsteady motion, transonic and hypersonic flows, atmospheric reentry.

511. AERODYNAMICALLY INDUCED NOISE (3) Review of fluid mechanics. General theory of aerodynamic sound. Noise radiation from jets, boundary layers, rotors and fans. Structural response. Prerequisite: Aersp. 412.

512. VISCOUS FLOW (3) Stress-deformation relations; Newtonian fluids, Navier-Stokes equations; exact, asymptotic laminar solutions; instability, transition; similitude and turbulent boundary layer.

514. STABILITY OF LAMINAR FLOWS (3) The stability of laminar motions in various geometries as influenced by boundary conditions and body forces of various kinds.

515. FOUNDATIONS OF TURBULENCE (3) The mathematics underlying turbulence theory: descriptions, kinematics of stochastic fields; techniques of solution of linear and some nonlinear problems.

516. HOMOGENEOUS TURBULENCE (3) Dynamics: production, spectral transfer, dissipation, decay of energy; similarity theories.

517. INHOMOGENEOUS TURBULENCE (3) Dynamics: similarity, structural hypotheses; spatial, spectral budget of energy in a number of classical flows.

518. DYNAMICS AND CONTROL OF AEROSPACE VEHICLES (3) Dynamical problems of aircraft and missiles including launch, trajectory, optimization, orbiting, reentry, stability and control, and automatic control. Prerequisite: Aersp. 413 or 450.

550. ASTRODYNAMICS (3) Applications of classical celestial mechanics to space flight planning. Determination and construction of orbital parameters by approximation methods. Perturbation techniques. Prerequisite: Aersp. 450 or Astro. 460 or E.Mch. 410 or Phys. 419.

AGRICULTURAL ECONOMICS (AG EC)

LEE M. DAY, *Head of the Department of Agricultural Economics and Rural Sociology*
6A Weaver Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members Becker, Bennett, Brandow, Day, Frey, Gamble, Hutton, Jansma, Madden, McAlexander, Partenheimer, Pasto, Pierce, Stemberger, and Trotter.
Graduate Faculty: Associate Members Epp, Hallberg, Herrmann, Holt, and Schutjer.

The graduate program emphasizes economic theory and analytical techniques in the fields of farm management, production economics, agricultural marketing, resource economics, agricultural policy and prices, and in international agricultural trade and development.

There is no foreign language requirement for the Ph.D. degree; rather, the student must satisfactorily complete courses in economic theory and quantitative methods.

The entering student in the master's program should have as prerequisites 3 credits in agricultural economics, 3 credits in economics, and 3 additional credits in either agricultural

economics or economics. If a student lacks some of the prerequisites, he may take them without graduate credit during the early part of his master's program.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

AGRICULTURAL ECONOMICS (AG EC)

407. Advanced Farm Management (3) *Mr. Partenheimer*
410. Agricultural Finance and Appraisal (3) *Mr. Holt*
420. Agricultural Prices (3) *Mr. Bennett*
421. Land Economics (3) *Messrs. Frey and Gamble*
422. Land and Water Resource Policy (3) *Mr. Jansma*
450. International Agricultural Trade and Development (3) *Mr. Schutjer*
460. Industrial Organization in Food Processing and Distribution (3) *Mr. Brandow*
461. Decision Making in Agricultural Marketing Firms (3) *Mr. Stemberger*

500. Seminar in Agricultural Economics (1-6) Review of current literature and problems.

504. Seminar in Agricultural Policy (3) Analysis of farm prices, income consequences for producers and consumers, and effects on resource use; evaluation of policy, considerations in policy making. Prerequisites: Ag.Ec. 420, Econ. 405. Odd years. *Mr. Brandow*

505. Advanced Agricultural Statistics (3) Multiple correlation, curve fitting, analysis of variance, and other techniques applicable to the rural social sciences. Prerequisite: 3 credits in statistics. *Mr. Bennett*

507. Seminar in Farm Management (1-6) Special problems relating to organization and operation of the farm business. Prerequisites: Ag.Ec. 6, Econ.14. *Mr. Partenheimer*

509. Concepts of Econometric Theory (3) Concepts underlying the application of econometric methods to economic problems; identification and multiple equation models; hypothesis testing and decision theory. Prerequisites: Econ. 502, 503.

514. Survey Research Techniques in Agricultural Economics (3) Survey methods and design of samples for obtaining economic data from business-unit and household populations. Prerequisite: Ag. 400. Odd years. *Mr. Bennett*

515. Economic Problems in the Marketing of Dairy Products (3) Economic problems as they are encountered in the process of marketing; particular attention to governmental regulation in pricing and marketing. *Mr. Pierce*

520. Farm Price Analysis (3) Econometric analysis of prices, production, and utilization of farm products; review of research in this field. Prerequisites: Ag.Ec. 420, 505; Econ. 405. Even years. *Mr. Hallberg*

524. Resource Economics (3) Economic aspects of resource use and development: economic growth, land-use planning and control, conservation, resource investment criteria and policies. Prerequisite: Ag.Ec. 421 or 422. *Mr. Epp*

525. Research Methods in Rural Social Sciences (2) Scientific method in planning and conducting research. Prerequisite: 9 credits in social sciences. *Mr. Brandow*

527. Seminar in Applied Quantitative Methods (1-4) *Messrs. Hallberg and Partenheimer*

534. Agricultural Production Economics (2) Economic theory applied to agricultural production problems: resource combinations, firm size, uncertainty and expectations, aggregate aspects of production, technological change. Prerequisite: Econ. 502. *Mr. Partenheimer*

535. Seminar in Agricultural Marketing (2)

550. Food Consumption Economics (3) Demand theory and research methods applied to the market for foods. *Mr. Herrmann*

571. Seminar in Land and Water Resource Economics (3) Critical review of research in resource economics; consideration of special topics in resource use.

AGRICULTURAL EDUCATION (AG ED)

DAVID R. McCLAY, *Head of the Department*
102 Armsby Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members McClay, Stevens, and Stinson.
Graduate Faculty: Associate Members Anthony, Curtis, and Hoover.

Graduate programs emphasize the professional improvement of teachers. They provide advanced preparation for employment in administration, supervision, teacher education, and research in agricultural education and related fields. A minor may be taken in an area of agricultural science, technology, business, or in general studies. Programs may include courses needed for certification in other fields of education.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by an intermediate knowledge of two foreign languages, by substitution of courses from other designated areas for one of these languages, or by a comprehensive knowledge of one foreign language.

Prerequisite to admission is a minimum of 18 credits in professional education courses or certification as a teacher of agriculture. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

AGRICULTURAL EDUCATION (AG ED)

400v. Educational Programs in Agriculture for Developing Countries (3)
418v. Survey of Vocational Education in Agriculture (1-4)
420v. Instructional Media in Agriculture (1-6)
422v. Supervision of Vocational Education in Agriculture (1-4)
424v. Occupational Guidance in Agricultural Industry (1-4)
426v. Adult Education in Agriculture (1-4)
434v. Agricultural Developments (1-6)

501v. Agricultural Education in the United States (1-3) Historical development, social and philosophical foundations, and current status in relation to the total vocational-technical education program.

502v. Teaching Agriculture (1-3) Vocational education objectives, learning theory, class instruction, cooperative occupational experience, and evaluation.

503v. Research in Agricultural Education (1-6 per term) Individual study problems in various phases of agricultural education, such as evaluation of teaching, teaching procedures, and teacher preparation.

504v. Agricultural Education Seminar (1 per term)

508v. Administration and Supervision of Agricultural Education (1-3) Administration of state and district systems of vocational-technical education; supervision of teachers of agriculture.

509v. Teacher Education in Agriculture (1-6) Organization and administration of university programs of teacher education in agriculture, including preservice preparation, continuing education, research, and other services.

520v. SCIENTIFIC METHOD IN THE STUDY OF AGRICULTURAL EDUCATION (1-4) Methods of procedure in investigation and experimentation in education, accompanied by a critical examination of studies made in agricultural education.

521v. SCIENTIFIC METHOD IN THE STUDY OF AGRICULTURAL EDUCATION (1-4) Continuation of Ag.Ed. 520v; emphasis upon statistical techniques for students' individual problems.

524v. PROGRAM DEVELOPMENT IN AGRICULTURAL EDUCATION (1-3) Analysis of occupational needs of students and employment prospects; organization of courses of study and other activities of teachers.

530. AGRICULTURAL COLLEGE TEACHING (3) Selection and organization of subject matter for specific courses, methods of learning, teaching devices, techniques of teaching, and measurements of results of teaching.

AGRICULTURAL ENGINEERING (AG E)

FRANK W. PEIKERT, *Head of the Department*
250 Agricultural Engineering Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Aldrich, Mohsenin, Peikert, and Persson.
Graduate Faculty: Associate Members Bartlett, Keppeler, Kjelgaard, Morrow, Myers, Schroeder, and Stephenson.

Graduate programs are available in the areas of physical properties of agricultural materials; plant and animal environmental engineering; agricultural processing and food engineering; agricultural mechanization with emphasis on forage, fruits, and vegetables; rural sanitation and conservation engineering; and computer technology applied to agricultural engineering problems.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by either (1) 9 credits of courses in humanities and social science or (2) a foreign language.

Excellent facilities, including equipment and instrumentation, are available for research in the designated areas. Among the special facilities are freeze-drying equipment for drying by sublimation, controlled environmental chambers, plant growth structures for modified atmosphere, a general purpose analog computer, and a laboratory for research on mechanical and rheological properties of agricultural materials. Laboratories are available with universal testing machines, equipped with accessories such as programmers and environmental chambers; a polariscope for photoelastic stress analysis; and acoustical and light reflectance instrumentation for research on the physical and rheological properties of agricultural materials.

Prerequisite to major work is the completion of an undergraduate major in engineering. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

AGRICULTURAL ENGINEERING (AG E)

400. AGRICULTURAL ENGINEERING PROBLEMS (1-7)
401. FARM MECHANICS FOR TEACHERS OF VOCATIONAL AGRICULTURE (1½-9)
402. FUNCTIONAL DESIGN OF AGRICULTURAL STRUCTURES (3)
403. PHYSICAL PROPERTIES OF AGRICULTURAL MATERIALS (3)
404. AGRICULTURAL MACHINERY (3)
405. AGRICULTURAL PROCESS ENGINEERING (3)
407. SOIL WATER ENGINEERING (3)
408. INSTRUMENTATION FOR AGRICULTURAL PRODUCTION AND PROCESSING (3)
409. AGRICULTURAL SYSTEMS ENGINEERING (3)

410. Power for Agricultural Systems (3)
412. Physical Processes in Food Manufacturing I (3)
413. Physical Processes in Food Manufacturing II (3)
414. Physical Processes in Food Manufacturing III (2)
420. Seminar (1)
423. Physical and Rheological Measurements on Biomaterials (3)

500. Advanced Electro-Agriculture (1-6) Investigations in the application of electrical energy to processing, storing, and handling agricultural products. Seminar, written reports.

501. Advanced Farm Machinery (1-6) Application of agricultural engineering principles to design and operation of farm machinery. Prerequisite: Ag.E. 410.

502. Farm Structures Problems (1-6) Analysis of farm structures design problems.

503. Physical Properties of Plant and Animal Products (3) Physical characteristics; mechanical, rheological, thermal, electrical, and optical properties in relation to handling, storage, processing, and quality evaluation.

505. Experimental and Applied Instrumentation (4) The theory and application of electronics for instrumentation and experimental research.

507. Problems in Soil Water Engineering (1-6) Analysis of engineering problems relating to irrigation, drainage, or erosion control.

508. Advanced Problems in Farm Mechanics (1-15) Problems in farm shop practice and agricultural engineering related to the farm mechanics program of vocational education in agriculture. Prerequisites: Ag.E. 8, 14; or teaching experience in farm mechanics.

509. Research in Agricultural Engineering (1-4)

520. Agricultural Engineering Seminar (1-3) Reports on research and special topics.

AGRONOMY (AGRO)

JAMES L. STARLING, *Head of the Department*
117 Tyson Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members Baker, Barnes, Cleveland, Cunningham, Duich, Fortmann, Harrington, Hill, Hunter, Jung, Kardos, Kendall, Marshall, Matelski, McKee, Petersen, Richer, Starling, Thomas, and Washko.

Graduate Faculty: Associate Members Bollag, Cole, Fritton, Hall, L. Johnson, M. Johnson, Marriott, Pfeifer, Risius, Shenk, and Waddington.

Areas of specialization include soil chemistry; soil conservation; soil classification; soil fertility; soil mineralogy; soil physics; the genetics and breeding of corn, small grains, and forage plants; forage management; turf management; potato culture; tobacco culture; weed control; and ecology of crops and pastures.

The communication and foreign language requirement for the Ph.D. degree may be met either by demonstrating a knowledge of at least one foreign language or by completing at least 6 credits of course work in a specialized area approved by the student's advisory committee.

Prerequisites for major work in agronomy vary with the area of specialization, but basic courses in chemistry, mathematics, physics, and biological sciences are required. Students who lack some of the course prerequisites may be admitted but are required to take the prerequisite courses without degree credit.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

AGRONOMY (AGRO)

411. Breeding of Field Crops (3) *Mr. Johnson*
415. Soil Morphology, Mapping, and Classification (3) *Mr. Petersen*
416. Soil Genesis (3) *Mr. Ciolkosz*
417. Forest Soils (3) *Mr. Pennock*
419. Soil Properties (4) *Mr. Baker*
422. Soil Conservation (3) *Mr. Cunningham*
423. Pasture and Grassland Management (3) *Mr. Washko*
424. Fertilizer Technology (3) *Mr. Marriott*
425. Principles of Field Crop Production (3) *Mr. Pfeifer*
431. Soil Fertility and Management (3) *Mr. Marriott*
438. Principles of Weed Control (3) *Mr. Hartwig*
490. Agronomic Problems (1-6) *Mr. Washko and Staff*

501. Advanced Soil Fertility (4) Interpretation of fertility experiments and diagnosis of soil-plant relationships through field appraisal, analysis, and plant symptoms. Prerequisite: Agro. 431, Biol. 441. *Mr. Hunter*

503. Agronomy Seminar (1) Weekly meeting where papers and discussions will be presented by students and staff members.

506. Soil Chemistry (4) Analyses of important chemical and biochemical reactions occurring in soils, conditions which control these reactions and their importance in soil genesis and plant growth; laboratory work in the more typical and significant analytical procedures; lectures, review of current literature, and practicum. Prerequisites: Agro. 419; Bioch. 425 or Chem. 451. *Mr. Baker*

507. Soil Physics (4) Physical properties of the soil; factors affecting them; their measurements, evaluation, and influence in determination of soil productivity. Prerequisites: Agro. 419, Bioch. 425, Phys. 215. *Mr. Kardos*

509. Genetics of Crop Plants (3) Inheritance in crop plants with particular reference to factor interaction, genetic aspects of linkage and crossing-over, quantitative inheritance, and heterosis. Prerequisite: Biol. 422. *Mr. Cleveland*

510. The Application of Cytogenetics to Plant Breeding (3) Cytogenetics, including chromosome structure and behavior, chromosome alterations, polyploidy, interspecific hybridization, and their applications to plant breeding. Prerequisite: Biol. 422. *Mr. Cleveland*

512. Field Plot Technique (4) Ramifications of analysis of variance techniques; combining and analyzing data from several experiments; selection of valid error terms. Prerequisite: Stat. 200 or Ag. 400. *Mr. Risius*

516. Humus (2) Origin and chemical nature of soil organic matter, its importance in soil processes, and its decomposition. Prerequisites: Agro. 419, 431. *Mr. Richer*

517. Farm Crops Ecology (3) Ecological factors affecting growth and development of farm crops with particular reference to effects of altered environment and management practices. Prerequisites: Agro. 28, Biol. 441. *Mr. McKee*

518. Growth and Management of Forage Crops (3) Factors affecting growth and development of forage crops with particular reference to effects of environment, defoliation, and management practices. Prerequisites: Agro. 423, Biol. 441. *Mr. McKee*

519. The Nature of Soil Minerals (3) Modern methods for identification of the constituent minerals of soils and their relation to soil classification and agricultural practices. Prerequisites: Agro. 419, G.Sc. 23. *Mr. Johnson*

545. The Application of Statistics to Field Experiments (4) Use of advanced experimental designs in planning, analyzing, and interpreting experiments; includes lattice designs, factorials, confounding, simple and multiple covariance techniques. Prerequisite: Agro. 512. *Mr. Starling*

*550. Agronomic Problems (1-12) Provides training in selected areas of agronomy by means of supervised investigations or studies.

582. Seminar in the Breeding and Genetics of Farm Crops (1 per term)

*Credits 1-6 per term.

AMERICAN STUDIES (AM ST)

IRWIN RICHMAN, *Chairman, Social Science Program*
The Capitol Campus, Middletown, Pa. 17057

Degree Conferred: M.A.

Graduate Faculty: Senior Members Lear, Richman, Tischler, and G. Wolf.
Graduate Faculty: Associate Members Anderson, Eisenstein, Knight, McAree, Patterson, and M. Wolf.

This program emphasizes the study of American society as a whole, not as interpreted by a single discipline, but in the larger context of a culture. The purpose of the program is to provide the student with the opportunity to acquire knowledge and understanding within any of the following areas: ethnic composition and demographic problems of the American people; regional characteristics; the technological base of American civilization; economic, political, and social institutions; the media of communication; artistic expression, particularly in art, architecture, literature, and music; philosophy and values; and the dynamics and interrelationships of all of these.

The student is required to take a minimum of 30 credits, including at least 18 credits in the 500 series. A maximum of 24 of these 30 credits shall be taken within the program area. An original, scholarly master's paper or creative production initiated by the student, supervised by an appropriate professor, and judged by a committee is required. One to six credits can be accumulated during work on the master's production.

For admission, a student must have received a baccalaureate degree from an accredited institution, earned under residence and credit conditions for the master's program. Social sciences or the humanities are not required as prerequisites, though it is anticipated that students will have had work in these areas. The application, transcripts, and a letter outlining personal goals and reasons for applying for the program should be sent directly to the Graduate Office, The Capitol Campus, Middletown, Pa. 17057.

REQUIRED COURSES

AM.ST. 500. THEORY AND METHODS (3) Study of the methods and materials of American Studies scholarship, compilation of bibliographies, the writing of scholarly papers, and proper documentation.

AM.ST. 580. PRODUCTION IN AMERICAN STUDIES (1-6) An original and independent exploration of some area of American Studies.

APPROPRIATE COURSES may be taken from the following list and from 500-level courses in other fields with the concurrence of the student's adviser.

AM.ST. 511. PIVOTAL BOOKS (3) Exploration of a number of books which have been particularly influential in shaping thinking about American civilization.

AM.ST. 530. MATERIAL CULTURE (3) Consideration of the techniques for studying material culture and of historical and regional patterns of material culture in America.

AM.ST. 533. AMERICAN CIVILIZATION IN THE EIGHTEENTH CENTURY (3) Detailed investigation of specific topics in eighteenth-century American civilization.

AM.ST. 534. AMERICAN CIVILIZATION IN THE NINETEENTH CENTURY (3) Representative interdisciplinary investigation of social, historical, economic, and aesthetic forces predominant in nineteenth-century America.

AM.ST. 535. AMERICAN CIVILIZATION IN THE TWENTIETH CENTURY (3) Detailed investigation of specific periods or topics in twentieth-century American civilization.

AM.ST. 569. AMERICAN SCIENCE AND MEDICINE PRIOR TO THE CIVIL WAR (3) An exploration of how scientific and medical thought mirrors the emergence of American culture.

ADDITIONAL COURSES may be taken from the following list and from 400-level courses in other fields with the concurrence of the student's adviser.*

AM.ST. 401. FOUNDATIONS OF AMERICAN CIVILIZATION
AM.ST. 422. WESTERN MOVEMENT
AM.ST. 431. THE AMERICAN CHARACTER
AM.ST. 442. AMERICAN FOLKLORE
AM.ST. 445. AMERICAN PHILOSOPHY
AM.ST. 451. CIVIL WAR AND RECONSTRUCTION
AM.ST. 452. THE AMERICAN RENAISSANCE
AM.ST. 453. THE GILDED AGE AND THE PROGRESSIVE IMPULSE
AM.ST. 454. AMERICA'S POLITICAL PARTIES
AM.ST. 455. REALISM AND NATURALISM IN AMERICAN SOCIETY
AM.ST. 456. MASS CULTURE: THE POPULAR ARTS IN AMERICA
AM.ST. 457. IMMIGRANTS AND AMERICANS
AM.ST. 458. CONTEMPORARY AMERICA
AM.ST. 459. AMERICA'S COMING OF AGE 1914-1939
AM.ST. 460. AMERICAN ART AND ARCHITECTURE
AM.ST. 463. AMERICAN MUSIC
AM.ST. 470. REGIONALISM IN AMERICA
AM.ST. 471. THE AMERICAN POLITICAL NOVEL
AM.ST. 474. (ECON. 474) AMERICAN ECONOMIC DEVELOPMENT
AM.ST. 479. UNITED STATES DIPLOMATIC HISTORY
AM.ST. 480. MUSEUMS AND CULTURE
AM.ST. 491. SENIOR SEMINAR IN AMERICAN CULTURE
AM.ST. 498. *SPECIAL TOPICS
SO.SC. 402. STUDIES IN AMERICAN SOCIETY
SO.SC. 403. CONTEMPORARY U.S. FOREIGN POLICY
SO.SC. 470. THE PRESIDENCY AND THE EXECUTIVE PROCESS

ANATOMY (ANAT)

BRYCE L. MUNGER, *Chairman of the Department*
The Milton S. Hershey Medical Center

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Baird, Ha, Munger, and B. Pubols.
Graduate Faculty: Associate Member L. Pubols.

The graduate program emphasizes the general areas of gross anatomy, histology/cytology, neuroanatomy/neurophysiology, or appropriate combinations of these areas. Approaches offered include morphological (descriptive, comparative, developmental), functional (physiological, chemical), and experimental. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

A bachelor's degree reflecting a reasonable background in zoology or biology, mathematics, and chemistry is required. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Applicants must provide complete transcripts and two letters of recommendation. Scores from the Graduate Record Examination and a personal interview are desirable.

This program is offered only at The Milton S. Hershey Medical Center.

*Descriptions of these courses may be found in *The Capitol Campus Catalog.*

ANATOMY (ANAT)

501. Gross Human Anatomy (3) Macroscopic organization of the extremities and head and neck with emphasis on anatomical individuality, functional significance, and clinical correlations.

502. Gross Human Anatomy (3) Macroscopic organization of the abdomen, thorax, and pelvis with emphasis on anatomical individuality, functional significance, and clinical correlations.

505. Microscopic Anatomy (3) Microscopic organization of tissues and cells; interrelationships of cells; chemical and functional specializations of cells.

510. Neurobiology (3) Morphology and function of the sense organs, general organization of the brain, and physiological studies of central nervous system function.

512. Human Embryology (2) Detailed study of normal development and physiology of the embryo and fetus; attention to developmental anomalies and fertilization problems.

530. Dissection (2-4) Individual dissection of a particular region of the body, study of the pertinent literature, and preparation of a report.

535. Submicroscopic Anatomy (3) Current literature on molecular and micellar organization of cells and tissues in diverse systems; application of interference and electron microscopy.

540. Seminar (1 per term) Student and staff presentations designed to evaluate current research developments in anatomy.

542. Comparative Neurology (3) A study of comparative aspects of central nervous system organization as related to phylogenetic development. Prerequisite: Anat. 510.

543. The Peripheral Nervous System (3) A study of the somatic sensory and motor systems. Prerequisite: Anat. 510.

545. Comparative Vertebrate Otology (3) Evolution and principles of the auditory system demonstrated by comparison of structures in ears of vertebrates; independent study expected.

550. Seminar in Quantitative Optics (3) Study of the various types of light microscopy instruments and application of these tools to quantitative measurements in biological systems. Prerequisite: Anat. 505.

570. Special Topics (1-6) Introduction of students to the research laboratory and scholarly pursuits of members of the staff; credit arranged by consultation.

590. Research Problems (1-12) Individualized research conducted by students in departmental laboratories. The program and credits to be arranged by consultation.

ANIMAL INDUSTRY (A I)

B. R. Baumgardt, *Head of the Department of Animal Science*
325 Animal Industries Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members Baumgardt, Cowan, Gobble, Long, Sink, Wilson, and Ziegler.
Graduate Faculty: Associate Members Cash, Merritt, Sherritt, and Wangsness.

A student may specialize in animal breeding, feeding, management, and meat science. The communication and foreign language requirement for the Ph.D. degree may be satisfied by proficiency in either one foreign language or communications skills (technical writing and speech).

For admission the student must complete an undergraduate major in animal science or a closely related field. Students who lack some of the course prerequisites may be admitted but are required to take the prerequisite courses without degree credit. Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The

best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests.

ANIMAL INDUSTRY (A I)

400. Special Topics (1-6)
405. Meat Animal Management (4)
421. Science of Meat (3)
423. Advanced Livestock Selection (2)
424. Animal Industry Seminar (1)
431. Advanced Meat Selection and Grading (2)

501. Pedigree Study (1-6) Research work in breed study history, and analytical study of breed pedigrees, and a complete survey of the herd, flock, or stud book.

502. Research in Meats (1-6 per term) Investigation of methods for handling, cutting, processing, freezing, and curing meat and meat products. Prerequisite: A.I. 421.

505. Advanced Animal Breeding (1-5) Special problems in animal genetics as applied to breeding and improvement of horses, cattle, sheep, and swine. Prerequisite: An.Sc. 322.

510. Animal Science Research Methods (3) Application of scientific method; experimental design and procedures; analyzing, interpreting, and reporting research results. Prerequisite: Ag. 400.

514. Animal Growth and Development (3) Animal life cycles; nature of growth and development; effects of biological, environmental, social, and psychological variants; homeostasis and organismic theory. Prerequisites: 3 credits in biochemistry and 3 credits in physiology.

Note: *See Animal Science under "Other Elective Graduate Courses." Also see Food Science.*

ANIMAL NUTRITION (A NTR)

B. R. Baumgardt, *Chairman of the Committee on Animal Nutrition*
325 Animal Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Baumgardt, Buskirk, Cowan, Gobble, Hartsook, Hershberger, Kesler, Leach, Long, McCarthy, Mendez, and Mueller.
Graduate Faculty: Associate Members Kollias, Martin, Scholz, Shellenberger, and Wangsness.

This is an interdepartmental graduate program designed to enable students to obtain thorough training in animal nutrition. The program is under the direction of a committee composed of graduate faculty members of the Departments of Animal Science, Dairy Science, Poultry Science, Veterinary Science, and the Human Performance Research Laboratory. Programs are offered in ruminant and nonruminant nutrition, including: physiology of nutrition; nutritional requirements for productive functions; metabolism of carbohydrates, lipids, proteins, vitamins, and minerals; and regulation of food intake and other metabolic functions.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign languages.

Undergraduate preparation should include organic and analytical chemistry, physics, biology, and mathematics. Students may be admitted with limited deficiency, but are required to make up undergraduate deficiencies without graduate credit.

Students should have an appropriate background and a 3.00 average in the major area and in related sciences for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum requirements may be made for students with special backgrounds, abilities, and interests.

The following nutrition courses are offered by participating departments, and their descriptions may be found under the listings of the respective departments: D.Sc. 511, Pty.Sc. 502. Courses related to animal nutrition can be found under the following listings in this bulletin: Animal Industry, Biochemistry, Dairy Science, Nutrition, Physiology, Poultry Science, and Veterinary Science.

ANIMAL NUTRITION (A NTR)

400. Nutrition and Feed Technology (3)
401. Physiology of Nutrition (3)
402. Energy and Protein Metabolism (3)

501. Energy Metabolism (2) Integration of biochemical and physiological processes in energy metabolism; concepts underlying the application of bioenergetics and calorimetry to body functions. Prerequisites: 3 credits each in biochemistry and physiology.

503. Micronutrients: Nutrition, Metabolism, and Function (2) Functional approach to the study of vitamins and trace elements in the nutrition and metabolism of animals and man. Prerequisites: 3 credits each in biochemistry, nutrition, and physiology.

505. Ruminology (3) Physiological, biochemical, and microbiological activities occurring within the rumen and the relation of rumen function to animal response. Prerequisites: at least one course in each of the following areas: animal nutrition, physiology, microbiology, and biochemistry.

Note: *See Animal Science listing under "Other Elective Graduate Courses."*

ANTHROPOLOGY (ANTHY)

Warren T. Morrill, *Head of the Department*
409 Social Sciences Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Baker, Chagnon, Escobar, Hunt, Matson, Michels, Morrill, and Sanders.
Graduate Faculty: Associate Members Dyke, Eckhardt, and Nydegger.

The master's program is designed to train students in general anthropology. The doctoral program is structured to train students in the following areas of specialization: new world archaeology, middle eastern archaeology, archaeological methodology, physical anthropology with special emphasis on human ecology; cultural ecology; Latin American ethnology; and peasant society.

M.A. candidates may submit either a thesis or a term paper. If the latter is chosen, 6 credits in 500-level courses in the major field must be scheduled in lieu of thesis credits. The M.A. degree may be bypassed by exceptional candidates for the Ph.D. degree.

The communication and foreign language requirement for the Ph.D. degree includes a reading knowledge of a foreign language plus an option from among additional foreign languages, field languages, linguistics, and statistics.

Undergraduate preparation must include 12 credits in anthropology and archaeology or their equivalent. A student with an excellent record but who does not meet these requirements may be admitted provided he makes up course deficiencies without graduate credit. Students with a 3.00 or above junior-senior average and with appropriate course backgrounds who have research interests directly related to the special anthropological competences within the department will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

ANTHROPOLOGY (ANTHY)

400. Human Evolution: The Material Evidence (3)
401. Human Evolution: Theory and Process (3)
402. Human Ecology (3)
403. Applied Physical Anthropology (3)
405. Primatology (3)
408. Demographic Methods in Anthropology (3)
409. Analytic Methods Laboratory (1)
420. Archaeology of the Near East (3)
421. Archaeology of the Central Andes (3)
422. Archaeology of Meso-America (3)
423. Archaeology of Eastern United States (3)
424. Archaeology of Africa (3)
440. South American Tribal Societies (3)
441. Ethnology of the Andean Region (3)
442. European Peasantry (3)
444. Ethnology of Meso-America (3)
446. Ethnology of North America (3)
447. Ethnology of Sub-Saharan Africa (3)
449. Ethnology of Southeast Asia (3)
450. Comparative Social Organization (3)
451. Economic Anthropology (3)
452. The Anthropology of Hunting Societies (3)
453. (Soc. 453) Primitive Religion (3)
454. Political Anthropology (3)
455. Culture and Personality (3)
456. Cultural Ecology (3)
457. Language in Culture (3)
460. Anthropological Theory (3)
461. Methods in Cultural Anthropology (3)
462. Methods in Archaeology (3)
463. Field Linguistics (3)
471. History of Anthropological Theory (3)

501. Evolution of Human Behavior (3) The application of evolutionary theory to the study of man's structure, function, and culture. Prerequisite: Anthy. 21 or 401, and 3 additional credits in anthropology, sociology, or psychology.

502-503. Ecological Theory in Anthropology (3 each) Man's biology, culture history, and culture variation from the ecological perspective. Two-term enrollment required. Prerequisite: 6 credits in anthropology.

504. Social and Cultural Change (3) Theories and methods used in the analysis of social and cultural change.

505. Naturalistic Behavior of Nonhuman Primates (3) Comparative study of behavior including taxonomy, geographic distribution, ecology, territoriality, population composition, grouping patterns, individual and group interactional characteristics, communication.

506. Cultural Dynamics (3) Survey of the major theories of culture change with special reference to archaeological research.

507. The Biology of Human Adaptability (3) An exploration of the biological mechanisms which aid man's survival in a variety of environmental settings.

508. Research Problems in Culture History (3-9)

509. Seminar in Regional Studies (3-9) Research and analysis in selected world cultural areas, including ecology, prehistory, history, ethnography, and current status.

510. World Ethnographic Survey (3) General survey of world cultures and their historical development.

511. (Hl.Ed. 511) Health Implications in the Growth and Development of School Children (3) Child growth and development emphasis for teachers; medical inspection and examination; preschool program; early habit formations; behavior problems.

513. (Hl.Ed. 513) Health Implications in Maturity and Aging (3) Changes in the human body in maturity and aging; mechanisms of physiologic aging; implications for health and preventive medicine.

530. Individual Readings in Anthropology (1-6) Reading or research in selected aspects of general anthropology.

531. Individual Research in Anthropology (3-6)

545. Seminar in Anthropology (1-9) Critical analysis of research in selected areas of anthropology.

560. Anthropological Theory (3) Theory used in culture-historical, sociological, and psychological interpretations.

561. Field Methods in Anthropology (3-9) Individual field work in any aspect of anthropology, supervised by staff of professional rank.

562. Laboratory Methods in Anthropology (3-9) Supervised laboratory research, utilizing materials from physical anthropology or archaeology or cultural anthropology.

563. Seminar in Linguistic Anthropology (3-6) Organized research on special topics in linguistic anthropology.

ARCHITECTURAL ENGINEERING (A E)

Gifford H. Albright, *Head of the Department*
101 Engineering A Building

Degree Conferred: M.S.

Graduate Faculty: Senior Members McLaughlin and Tichy.
Graduate Faculty: Associate Members Albright and Summers.

Students may specialize in structural analysis and design, environmental control engineering, illumination, acoustics, materials of construction, building construction management, computer application to building design and performance, or nuclear defensive and protective construction. The latter area includes shelter planning, effects of nuclear weapons, shelter environmental requirements, analysis and design of blast-resistant structural systems, and integrated engineering requirement for protective construction.

For admission a student must have a strong background in some field of engineering; in engineering science or mechanics; or in architecture, psychology, economics, or management if there is adequate preparation in the physical sciences and mathematics. The detailed requirements depend upon the student's area of special interest.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

ARCHITECTURAL ENGINEERING (AE)

401. Architectural Engineering (3)
402. Architectural Engineering (3)
403. Architectural Engineering (3)
430. Architectural Engineering (3)
431. Architectural Engineering (3)
439. Architectural Engineering (3)
441. Integration of Architectural Engineering Systems (3)

442. Research in Architectural Engineering (1-6)
454. Environmental Engineering in Buildings—Design (3)
458. Advanced Architectural Acoustics and Noise Control (3)
464. Advanced Architectural Illumination Systems Design (3)
471. Building Construction Assemblies (3)
472. Building Construction Management I (3)
473. Building Construction Management II (3)
474. Building Cost Analysis (3)
475. Building Construction Engineering I (3)
476. Building Construction Engineering II (3)
477. Building Project Analysis (3)
481. Architectural Engineering Thesis (2)
482. Architectural Engineering Thesis (2)
483. Architectural Engineering Thesis (2)
486. Professional Engineering Practice (3)

502. Architectural Engineering (3-8) Advanced structural design in steel and reinforced concrete. Lectures and class criticism. Practicum and seminar.

503. Architectural Engineering (4-8) Continuation of A.E. 502 in which problems of wind bracing in tall buildings, rigid frames, and heavy-framed constructions are studied. Practicum and seminar.

542. Advanced Problems and Research in Architectural Engineering (2-12) Investigation, analysis, and preparation of comprehensive report on subject relating to special problems in architectural engineering systems.

545. Architectural Engineering Seminar (1-6) Current literature and special problems in architectural engineering; presentation of technical papers.

551. Advanced Nuclear Defense Planning and Design I (3) Weapons effects data; dynamic strength of materials and structural elements; dynamic design; architectural, structural, electrical, and mechanical requirements for shelters. Prerequisites: A.E. 4, 5; E.Mch. 12.

552. Advanced Nuclear Defense Planning and Design II (3) Blast-resistant design of framed structures, shear wall structures, arches, domes, and underground structures; radiation shielding characteristics of building materials. Prerequisites: A.E. 431, 432, 551; Phys. 237.

553. Selected Problems in Nuclear Defense Research (1-6)

ARCHITECTURE (ARCH)

Raniero Corbelletti, *Head of the Department*
308 Sackett Building

Degree Conferred: M.S.

Graduate Faculty: Senior Members Corbelletti, Golany, Pinno, and Strumillo.
Graduate Faculty: Associate Member Hallock.

Advanced studies are offered in architecture, urban design, and planning. The student is offered opportunity for independent research and extensive interdisciplinary work under the guidance of specialists and scholars in technical, cultural, industrial, and social fields. The nonthesis option is available for the M.S. degree.

For admission, a five-year bachelor's degree program in architecture is required.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

ARCHITECTURE (ARCH)

400. Special Projects (4-12)
408-409-410. Applied Architectural Design (5 each)
441. Architectural Design Analysis (3)
442. Architectural Design Analysis (3)
443. Architectural Design Analysis (3)
464. Architectural Systems — Comparative Analysis of Structure (1)
465. Architectural Building Materials (3)
471. Environmental Control Systems I (3)
472. Environmental Control Systems II (3)
475. Architectural Systems — Environmental Control (2)
490. Architectural Research (1-12)

515. New Towns Planning Seminar (3) Examination of the process, concepts, and structure of new towns planning as a response to contemporary urban-regional development problems.

516. New Communities Seminar (3) Examination and evaluation of the new communities movement in the United States.

530. Architecture I (4-12) Problems in architectural planning and design. Programming and/or implementation methodologies and applications for various environmental design scales.

531. Architecture II (4-12) Continuation of Arch. 530 with concentration and specialization options.

532. Comprehensive Planning Process Studio (4-12) Field case studies in analysis forecasting and projections of urban physical design elements. Preparation of comprehensive plan, regulations, and implementation.

535. New Towns Planning Studio (4-12) A team workshop of planning and design of new towns, involving data gathering, surveys, analysis, projection, and implementation.

591. Architectural Research (2-12) Guided research project.

ART (ART)

Robert H. Gray, *Head of the Department*
102 Visual Arts Building

Degrees Conferred: M.A., M.F.A.

Graduate Faculty: Senior Member McCoy.
Graduate Faculty: Associate Members Adams, Altman, Cook, DonTigny, Frost, Gray, Shobaken, and Zoretich.

The M.A. program is planned to provide a broad range of experience and study in the visual arts. A thesis in an area of specialization is required. Requirements for admission include a broad undergraduate training in art and the presentation of a portfolio or examples of the student's work.

The M.F.A. program is planned to provide professional emphasis in a specific area of art. A creative project and supporting monograph are required. Requirements for admission include 24 credits in studio art with some indication of concentration in a chosen area and a statement of purpose concerning the professional aims of the candidate. A portfolio, photographs, or examples of the student's work must be presented.

All students accepted for graduate study in art who lack the adequate undergraduate courses or show deficiencies in some area will be required to take additional course work without degree credit.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

ART (ART)

**411. Seminar in Contemporary Art (3)
*412. Individual Instruction (1-6)
*425. Advanced Drawing (3)
*430. Advanced Sculpture (3)
*448. Advanced Printmaking (3)
*450. Advanced Painting (3)
*460. Advanced Watercolor (3)
470. Graphic Design II (3)
471. Graphic Design III (3)
472. Exhibition Concepts and Structure (3)
473. Seminar in Design Research (3)
*480. Advanced Ceramics (3)
*495. Advanced Photography (3)

501. Art Research (2-6) Original study and practice in art relating to material, concept, or technique.

530. Advanced Sculpture (3-12) Individual projects in sculpture leading to the development of a collection or body of work representative of the artist.

545. Printmaking (2-12) Problems in printmaking leading to the development of a collection or body of work representative of the individual artist.

550. Painting (2-12) Individual problems in painting leading to the development of a collection or body of work representative of the artist.

570. Design (2-12) Individual projects in design with special emphasis on professional practice in specialized fields of graphic design.

580. Ceramics (2-12) Experimental problems in ceramics leading to the development of a collection or body of work representative of the individual.

ART EDUCATION (A ED)

HARLAN E. HOFFA, *Head of the Department*
269 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Beittel, Edmonston, Hoffa, and Stewart.
Graduate Faculty: Associate Members Bradley, Chomicky, and Schwartz.

This program prepares students for careers in public school art teaching, art supervision, college teaching, administration, or research. To be admitted without deficiencies, the student is expected to have completed either a baccalaureate program in art education or a program leading to certification. Such a program would include work in art studio, art history, art education, education, educational psychology, and psychology. Deficiencies may be made up by course work which is not counted as credit toward an advanced degree.

All students are expected to complete two years of teaching before receiving the doctor's degree. A foreign language is not required of all Ph.D. degree candidates. In lieu of a foreign language, the student will include a series of research and communications studies pertinent to his interests and to his graduate program and may include a foreign language approved by the doctoral committee.

*May be repeated for a total of 12 credits.
**May be repeated for a total of 6 credits.

Students with a 2.75 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.75 grade-point average may be made for students with special backgrounds, abilities, and interests. Transcripts should indicate high attainment in appropriate academic and creative work, and recommendations should attest to scholarship and ability to work independently. Creative work, as shown by slides and photographs, should show a high level of involvement and sensitivity to aesthetic forming processes.

Students who seek admission to the graduate program must make formal application to the Admissions Committee of the Department of Art Education.

ART EDUCATION (A ED)

401. Studies in Art Media (1-10)
404. Methods of Graphics and Illustrations (3)
414. Advanced Crafts for Teachers (3-6)
420. Ceramics for Teachers (3)
434. Art Appreciation in the Educational Program (3)
435. Art in the Elementary School (3)
436. Art in the Secondary School (3)
486. Current Problems in Art Education (2-3)
487. Mural Painting in Schools (3)
488. Advanced Mural Painting in Schools (3)
489. Art Experiences with Children (3)
490. Introduction to Research in Art Education (3)

501. Seminar in Art Education (1-6) The analysis of fundamental concepts derived from related disciplines; the examination of current problems; current literature.

504. Advanced Method in Graphic Processes (3) Exploration through laboratory experience of printing method: etching, silk screen, linoleum, or other; applications in teaching.

514. Functional Relationships in Crafts (3) Relationships of material design and purpose in crafts discussed by means of outstanding products of different materials, periods, and cultures. Prerequisite: 6 credits in crafts or 3 in design and 3 in advanced crafts.

516. Analysis of Three-Dimensional Processes in Art (3) Three-dimensional processes analyzed with regard to kinetic, textural, form, and other functions.

520. Advanced Ceramic Art (3) Intensified exploration of throwing, glazing, and firing processes as related to aesthetic considerations in contemporary art forms and past cultures. Prerequisite: A.Ed. 420.

535. Administration and Supervision of Art Education Programs (3) The problems and responsibilities of the city, county, and state art supervisor; curriculum, facilities, financing, supervision, in-service training, and reporting. Prerequisites: A.Ed. 435, 436.

536. Curriculum Development in Art Education (3) Factors affecting art curriculum decisions, analysis, selection, organization, preparation of curriculum. Evaluation and sources of art curriculum improvement and innovation. Prerequisite: 6 credits of methods.

588. History of Art Education (3) Historical development of philosophies in art education in the United States and abroad.

589. Research Methods in Art Education (3-6) Orientation in research methods; findings and designs related to the study of problems in art education.

595. Research in Art Education (1-6) Independent research, under an adviser, to be terminated by a scholarly report proportionately comparable in quality to a master's thesis. Prerequisite: 15 credits in art education on the 400 and 500 levels, including A.Ed. 589.

ART HISTORY (ART H)

HELLMUT W. HAGER, *Head of the Department*
229 Arts II Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Battisti, Cutler, Hager, Hyslop, Mauner, van der Meulen, and Weisman.
Graduate Faculty: Associate Member Kiang.

Graduate work is offered in the following areas: ancient art, medieval and Byzantine art, Renaissance and baroque art, and modern art. Special research opportunities are available through the Center for the Study of Renaissance and Baroque Art.

Candidates for the M.A. degree are required to complete a master's thesis and to demonstrate a reading knowledge of two foreign languages, one of which must be German. The other language is normally French or Italian. Reading knowledge of one of these languages should be demonstrated at the end of four terms of study. Another examination for the second language will be given before the end of one year of study. These regulations apply equally to Ph.D. students. For those students wishing to enter the doctoral program who have already completed a master's degree from another university, a reading knowledge of one foreign language will be required before the student can be considered for admission to the department.

Candidates with a 3.00 junior-senior grade-point average and a minimum of 18 credits in art history will be considered for admission to the master's program. Lacking these, a promising candidate may be accepted on condition that he make up the deficiency without graduate degree credit. The best qualified applicants will be accepted up to the number of spaces that are available for new students.

ART HISTORY (ART H)

400. STUDIES IN ART HISTORY (3-6 per term)
401. STUDIES IN GREEK ART (3)
402. THE ILLUMINATED MANUSCRIPT (3)
405. PIONEERS OF MODERN ARCHITECTURE (3-6)
410. TASTE AND CRITICISM IN ART (3)
411. ART OF IMPERIAL ROME (3)
412. THE GOTHIC CATHEDRAL (3)
414. STUDIES IN ITALIAN BAROQUE ART (3-9)
415. THE SKYSCRAPER (3)
416. AMERICAN PAINTING: 1876-1913 (3)
422. STUDIES IN MEDIEVAL SCULPTURE (3)
423. STUDIES IN ITALIAN RENAISSANCE ART (3-9)
424. MASTERS OF NORTHERN BAROQUE ART (3)
425. MOVEMENTS IN NINETEENTH-CENTURY ART (3)
432. PROBLEMS IN ICONOLOGY (3)
435. MOVEMENT IN TWENTIETH-CENTURY ART (3-6)

510. STUDIES IN ART HISTORY (3-6 per term) Original investigation in art history, to be pursued independently or concurrently with course work in particular fields.

511. SEMINAR IN ANCIENT ART (3-12) Selected topics from the history of Greek and Roman art.

512. SEMINAR IN MEDIEVAL ART (3-12) Original research into problems dealing with the art of the Middle Ages.

513. SEMINAR IN RENAISSANCE ART (3-12) Investigations in the area of Renaissance art, centering around major masters and monuments.

514. SEMINAR IN BAROQUE ART (3-12) Investigations in the area of baroque art centering around major masters and monuments.

515. SEMINAR IN MODERN ART (3-12) Lectures, readings, reports, and discussions in the field of modern art.

517. SEMINAR IN EIGHTEENTH-CENTURY ART (3-12) Investigation into themes and problems dealing with eighteenth-century art.

522. SEMINAR IN BYZANTINE ART (3-12) Specific iconographical and stylistic problems in Byzantine art and its relation to classical antiquity, the medieval West, and Islam.

525. SEMINAR IN MODERN ARCHITECTURE (3-12) Investigation into the works and problems of modern architecture as they relate to the culture of our times.

542. THE ILLUSTRATION OF THE APOCALYPSE (3-6) Studies in the illustration of the Apocalypse, iconographical and stylistic, from the Early Christian period through Dürer.

555. ART HISTORY FIELD SEMINAR (3-12) Investigations based on the site study of specific art objects, with trips in successive years to different art centers.

ASTRONOMY (ASTRO)

JOHN P. HAGEN, *Head of the Department*
525 Davey Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Hagen, Matsushima, and Sampson.
Graduate Faculty: Associate Memebers Bauer, Usher, Winkler, and Zabriskie.

Graduate instruction and research opportunities are available in observational and theoretical radio and optical astronomy, including the sun and objects in the solar system, stellar and planetary atmospheres, variable galaxies, gaseous nebulae, theory of radiative transfer and atomic collisions, and stellar structure and pulsation theory. Research facilities include two off-campus observatories: (1) Radio Astronomy Observatory, including facilities for optical solar observations near the campus, and (2) an optical observatory near Black Moshannon for spectroscopic and photometric observations. The nonthesis option is available for the M.S. degree.

Modern astronomy has very close ties with mathematics, physics, and engineering. The program required of a doctoral candidate would normally include courses in at least two of these related fields, in addition to those in astronomy. A knowledge of computer programming may be substituted for one of the two foreign languages required.

Applicants with a bachelor's degree in astronomy, physics, mathematics, or electrical engineering are given equal consideration for admission. Opportunity to make up possible undergraduate deficiencies is provided. A grade-point average of 3.00 or better for junior-senior courses in astronomy and related subjects is necessary for consideration for admission, although exceptions to this minimum requirement may be made for students with special backgrounds, abilities, and interests.

ASTRONOMY (ASTRO)

430. GENERAL ASTRONOMY FOR TEACHERS (3)
460. FUNDAMENTALS OF CELESTIAL MECHANICS (3)
470. SOLAR PHYSICS (3)
490-491. INTRODUCTION TO ASTROPHYSICS (3 each)
492. (E.E. 492) SPACE ASTRONOMY AND INTRODUCTION TO SPACE SCIENCE (3)
495. PRACTICAL ASTRONOMY (3)

510. ASTROPHYSICS (3) An introduction to astrophysics in which the relevant physics, spectra, gas laws, plasmas, and radiation transfer theory are discussed.

511. ASTROPHYSICS (3) Stellar atmospheres; considerable emphasis is placed on the sun and on solar-terrestrial relationships. Prerequisite: Astro. 510.

512. ASTROPHYSICS (3) Stellar interiors, stellar evolution, pulsating stars, novae and supernovae; some discussions of the interstellar medium and gaseous nebulae. Prerequisite: Astro. 510.

513. OBSERVATIONAL TECHNIQUES IN ASTRONOMY (3) Radiation quantities in theory and as observed. Astrometry, photometry, spectroscopy, stellar classification, interferometric methods. Observational laboratory. Prerequisite: Astro. 511.

516. NONEQUILIBRIUM RADIATIVE TRANSFER THEORY (3) Detailed study of theory of radiative transfer when the assumption of local thermodynamic equilibrium is not made, with astrophysical applications. Prerequisite: Astro. 511 or Phys. 561.

520. GALACTIC STRUCTURE (3) Stellar clusters and associations, galactic dynamics, stellar populations, distance determinations, luminosity calibration, and stellar statistics.

523. OBSERVATIONAL THEORY (3) Information theory of noisy signals, statistics of nonlinear functions, theory and application of convolutions, selection effects, systematic errors, selected problems. Prerequisite: Astro. 513.

524. CELESTIAL MECHANICS AND SPHERICAL ASTRONOMY (3) Two-body and one-body theory, elliptic motion, expansions, two-body orbit in space, coordinate transformations, planetary equations. Lagrange and Hamilton mechanics. Prerequisites: Math. 452, Phys. 419.

530. THEORY OF STELLAR ATMOSPHERES (3) Theory of photospheric structure, radiative processes, and line-formation in the outer layers of stars, and interpretation of stellar spectra. Prerequisite: Astro. 511.

534. STELLAR STRUCTURE AND EVOLUTION (3) A detailed study of the theory of the interiors and evolution of stars. Prerequisite: Astro. 511 or Phys. 561.

542. GASEOUS NEBULAE AND INTERSTELLAR MATTER (3) Theory and observations of galactic nebulae and interstellar medium, and problems related to the formation of stars and galactic structure. Prerequisite: Astro. 511.

545. ASTROPHYSICAL PLASMA KINETIC THEORY (3) Kinetic theories, fluid behavior, collective phenomena, and collisional processes of plasmas and self-gravitating systems of gas and stars. Prerequisite: Phys. 530.

560-561. GENERAL RELATIVITY AND COSMOLOGICAL MODELS (3 each) Riemannian geometry; general relativity theory and experiments; massive bodies; and Newtonian, Einsteinian, and steady state cosmologies are studied. Prerequisite: Phys. 525.

582. RADIO ASTRONOMY (3) Radiometers and antennas; signals in noise; solar physics; quiet and active solar radiation; transfer equation and solar radiation; solar-terrestrial effects. Prerequisite: E.E. 438 or Phys. 467.

583. RADIO ASTRONOMY (3) Radio astronomical studies of the moon and planets, galactic and extragalactic sources, and the structure of galaxies using line spectra. Prerequisite: Astro. 582.

BIOCHEMISTRY (BIOCH)

JOHN H. PAZUR, *Head of the Department*
108 Althouse Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Clagett, Hartzell, Mallette, McCarl, Pazur, Phillips, R. Schraer, and Shigley.
Graduate Faculty: Associate Members Aronson, Fahnestock, Hammerstedt, Niehaus, Warme, and Winter.

Opportunities for research and graduate study are available in intermediary metabolism, cellular control mechanisms, molecular genetics, enzyme structure, nucleic acids, proteins, carbohydrates, lipids, photosynthesis, and endocrinology.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by a reading knowledge of one foreign language.

Entering graduate students should have had at least one year's work in each of the following: general chemistry, analytical chemistry, organic chemistry, physical chemistry, and general physics. Mathematics through integral calculus is also required. Students with limited deficiencies in these subjects may be admitted but must make up such deficiencies concurrently with their graduate studies. Undergraduate courses in biology, biochemistry, and foreign languages will be helpful to the student but are not required for admission.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

BIOCHEMISTRY (BIOCH)

401. GENERAL BIOCHEMISTRY (3)
402. GENERAL BIOCHEMISTRY (3)
403. EXPERIMENTAL BIOCHEMISTRY (3)
417. BIOCHEMICAL METHODS (4)
425. INTRODUCTORY PHYSICAL BIOCHEMISTRY (4)
437. PHYSIOLOGICAL BIOCHEMISTRY (3)
438. PHYSIOLOGICAL METHODS (2)
439. INDEPENDENT STUDY (1-12)
451. SENIOR SEMINAR (1)

501. ENZYMES AND BIOCATALYSIS (2) Enzyme kinetics, mechanisms of enzymic catalysis, correlation of structure and function, regulation of catalytic activity, literature reports. Prerequisite: Bioch. 402.

503. BIOCHEMICAL PROBLEMS (1-10 per term) Prosecution of an assigned problem under the guidance of an instructor.

507. SEMINAR IN BIOCHEMISTRY (1 per term)

510. PROTEINS (2) Biochemical and physical properties of proteins and polypeptides, isolation and purification techniques, sequence analysis, conformational structure. Prerequisite: Bioch. 402.

511. CARBOHYDRATES (2) Stereochemistry, conformational analysis, and chemical reactivity of carbohydrates; biochemistry of monomeric and macromolecular carbohydrates. Prerequisite: Bioch. 402.

512. LIPIDS (2) The structure, biosynthesis and metabolism of fatty acids, glycerides, phospholipids and sterols. Prerequisite: Bioch. 402.

513. (Bphys. 513) BIOCHEMISTRY OF NUCLEIC ACIDS (2) Structure, reactions, synthesis, and biochemical properties of nucleic acids. Prerequisite: Bioch. 402.

515. THE BIOSYNTHESIS OF MACROMOLECULES (2) An enzymological approach to the biosynthesis of DNA, RNA, proteins, complex polysaccharides and membranes. Prerequisite: Bioch. 402.

519. TOPICS IN METABOLISM (2) Selected topics dealing with metabolism and metabolic control, literature reports; may be repeated once in successive years. Prerequisite: Bioch. 402.

530. CONTEMPORARY TOPICS IN BIOCHEMISTRY AND MOLECULAR BIOLOGY (2-4) Lectures and discussions by visiting lecturers on new and significant developments in biochemistry and molecular biology.

BIOENGINEERING (BIO E)

D. B. GESELOWITZ, *Chairman of the Program Committee in Bioengineering*
328 Hammond Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Adams, Anthony, Brickman, Brighton, Buskirk, Davids, Geselowitz, Jacobs, Kenney, Kline, Lumley, Michael, Munger, Rhodes, and Sharma.
Graduate Faculty: Associate Members Bishop, Fonash, Hollis, Morrow, Notter, Park, Phillips, Pierce, and Ultman.

This is an interdisciplinary program designed to provide the student with graduate level training in engineering and in the life sciences, and specialized training in specific areas of interaction of engineering with biology and medicine. Graduate instruction in bioengineering is under the direction of a program committee composed of Graduate Faculty representing several departments.

The particular course of study depends on the student's background and area of research specialization. Courses are selected from the life sciences, engineering, and bioengineering. Candidates for the Ph.D. degree generally are expected to complete Phsio. (Biol.) 571-574 plus several additional courses in the life sciences, five courses in bioengineering, and five graduate level courses in engineering, mathematics, and physics. Supporting courses are available at University Park and the Hershey Medical Center in anatomy, biochemistry, biology, biophysics, dairy science, laboratory animal medicine, physical education, physiology, chemistry, psychology, mathematics, engineering acoustics, material sciences, polymer science, and the engineering departments.

Opportunities for specialized research include electrical and mechanical properties of biological materials, development of an artificial heart, hemodynamics, electrocardiography, electroencephalography, applications to nuclear medicine and radiology, biomaterials, lung mechanics, bioinstrumentation, and transducers.

Students with a degree in engineering, physics, or the life sciences will be eligible for admission. All students must have a strong background in physics and mathematics. This background should include 9 credits in chemistry, including organic chemistry; 9 credits in physics; mathematics through calculus and differential equations; a course in physiology; and a course in linear systems and analysis. Students who lack one or two courses may still be considered for admission, but will have to make up any deficiency early in their graduate program. Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces available. Exceptions to the minimum grade-point average may be made for students with special backgrounds, abilities, and interests.

BIOENGINEERING (BIO E)

425. (Nuc.E. 425) RADIOGRAPHIC IMAGING (3)

BIOLOGICAL CHEMISTRY (BCHEM)

LOUIS F. HASS, *In Charge of Graduate Programs in Biological Chemistry*
The Milton S. Hershey Medical Center

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Davidson, Hass, and Rosenberg.
Graduate Faculty: Associate Members Hill, Miljkovic, Roark, Schengrund, and Shiman.

Opportunities for research and graduate study are available in the chemistry and metabolism of complex polysaccharides, cellular differentiation, mechanism of enzymatic reactions, biochemical genetics, biochemistry of complex lipids, conformational analysis of carbohydrates and proteins, natural product chemistry, and physical chemistry of macromolecules.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. Interested students should contact the Director of Graduate Programs.

Research and graduate study opportunities are also available in the Department of Biochemistry at University Park.

BIOLOGICAL CHEMISTRY (BCHEM)

502. BIOLOGICAL CHEMISTRY (5) Principles of biological chemistry with emphasis on the relationship of macromolecular structure to function in metabolic pathways and specialized tissues.

503. MOLECULAR GENETICS (2) Aspects of the mechanism and control of nucleic acid and protein biosynthesis with emphasis on their relationship to genetic phenomena.

513. BIOLOGICAL CHEMISTRY MACROMOLECULES (3) Methods of detailed determination of the three-dimensional structure of macromolecules, primarily enzymes and amino acid sequence and conformation of protein.

523. METABOLISM (3) Molecular mechanisms employed by living systems to transform biological compounds, control production and utilization of energy, and regulate metabolic pathways.

540. SEMINAR (1 per term) Critical discussion of current literature within a facet of biochemistry; experimental design, procedures, and interpretation of results to be emphasized.

551. KINETICS AND MECHANISM OF ENZYME ACTION (3) Current kinetic theory, rapid reactions, regulatory enzymes, chemical and physical approaches to the study of the mechanism of enzyme action. Prerequisite: B.Chem. 502. Concurrent: B.Chem. 523.

553. BIOCHEMICAL TECHNIQUES (3) Lectures and discussion on approaches to macromolecule separation and characterization, isolation of subcellular organelles and specialized procedures for tissue fractionation. Prerequisite: B.Chem. 502.

570. SPECIAL TOPICS (2) Discrete areas of contemporary research in conformational analysis and natural product structure, complex polysaccharide structure, neurochemistry, and biochemistry of disease.

590. RESEARCH PROBLEMS (1-12) Individualized research on biochemical problems conducted by students in departmental laboratories.

BIOLOGICAL SCIENCE (BI SC)

ANTON J. KOVAR, *Chairman of the Committee on Biological Science*
121 Buckhout Laboratory

Degrees Conferred: D.Ed., M.Ed.

Graduate Faculty: Senior Members Anthony, Bellis, Butler, Cooper, Dalton, Fergus, Gaffney, Grove, Grun, Hale, Hamilton, Hillson, Hymer, Keener, Kovar, O'Mara, Pursell, Schein, Spackman, Therrien, Traverse, Wagner, Wickersham, Williams, Witham, and Wright.
Graduate Faculty: Associate Members Abplanalp, Adams, Hollis, MacCluer, Mitchell, Neff, and Wood.

The M.Ed. program in biological science is designed primarily to meet the needs of secondary school science teachers. The academic degrees M.S. and Ph.D. are not offered in biological science but are available in biochemistry, biology, biophysics, botany, entomology, genetics, microbiology, physiology, plant pathology, and zoology.

The candidate for the M.Ed. degree must earn at least 21 credits in the natural sciences with a minimum of 15 credits in the biological sciences, including at least 6 in the animal sciences and 6 in the plant sciences. In addition, at least 6 credits in education and a term paper are required. It is suggested that the candidate have at least 2 years of teaching experience before applying to this program.

The D.Ed. program is designed for secondary school and college science teachers. Major course requirements are designated by the candidate's committee with the concept that teachers of biology have a broad background in biological disciplines and related fields. A minimum of 15 credits each is required in professional education and in thesis research. The requirement of a foreign language is at the discretion of the candidate's committee.

In order to enter a program for a higher degree with a major in biological science, the candidate should present 30 credits in the natural sciences, including one year of organic chemistry and one year of physics. A limited number of undergraduate deficiencies may be made up in pursuit of the advanced degree. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

BIOLOGY (BIOL)

JOSEPH G. O'MARA, *Head of the Department*
208 Life Sciences I Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Anthony, Bellis, Butler, Cooper, Dalton, Dunson, Fergus, Gaffney, Grove, Grun, Hale, Hamilton, Hibbard, Hillson, Hymer, Keener, Kneebone, Kovar, O'Mara, Pursell, Schein, Spackman, Therrien, Traverse, Wagner, Wickersham, Williams, Witham, and Wright.
Graduate Faculty: Associate Members Abplanalp, Adams, Hollis, MacCluer, Mitchell, Neff, and Wood.

The department will direct graduate programs in behavior, cell biology, cytology, cytochemistry, environmental science, ultrastructure, and other aspects of modern biology. The courses of study are planned individually by the student and an adviser. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language. Candidates have an option of a thesis or a paper for the M.S. degree.

Admission is restricted to students who have the baccalaureate degree in a biological science and who present a cumulative undergraduate average of at least 3.00. Each applicant must provide scores from the Graduate Record Examination, letters from two persons who are familiar with his academic competence, and a personal statement of his interests and objectives.

BIOLOGY (BIOL)

402. Vertebrate Neuroanatomy (3)
404. Practicum in Experimental Neuroanatomy (1-4)
405. General Cytology (3)
*406. Seminar in Neuroanatomy (1-6)
407. Plant Anatomy (3)
409. Biology of Aging (3)
410. General Limnology (3)
411. Plant Biology for Teachers (3)
412. Plant Biology for Teachers (3)
414. Advanced Systematic Botany (3)
417. Invertebrate Zoology (3)
418. Mycology (3)
419. General Ecology (3)
420. (Geol. 420) Paleobotany (3)
421. Comparative Anatomy of Vertebrates (4)
422. Advanced Genetics (3)
423. (Geol. 423) Introductory Palynology (3)
426. Introductory Cytogenetics (3)
427. (Geol. 427) Evolution (3)
428. Population Genetics (3)
430. (Bphys. 430) Molecular Biology of the Gene (3)
431. Comparative Plant Morphology (2)
432. Laboratory in Comparative Plant Morphology (2)
437. Histology (4)
440. Embryology (4)
441. Plant Physiology (3)
442. Plant Physiology (3)
443. Plant Physiology (3)
444. Biological Problems (1-6)
445. Phytohormones (3)
448. Ornithology (3)
450. Plant Autecology (3)
451. Plant Synecology (3)
452. Ichthyology (3)
462. (Pty.Sc. 462) Animal Behavior — Ethology (3)
463. (Pty.Sc. 463, Psy. 463) Animal Behavior Laboratory (1-2)
472. Vertebrate Physiology (3)
473. Laboratory in Vertebrate Physiology (2)
475. Cellular Physiology (4)
479. General Endocrinology (3)
480. Marine Biology (4)
481. Aquatic Botany (3)
496. Current Topics in Biology (1-6)

500. Plant Physiology Seminar (1 per term) Selected topics from recent literature; staff and student reports on current research. Spring term, even years.

502. The Physiology of the Fungi (3) Chemical composition, metabolism, toxic and stimulating agencies, spore germination, growth and irritability of the fungi. Fall term, even years.

506. Comparative Anatomy of Vascular Plants (3) Structure of the Tracheophyta from a phylogenetic standpoint. Prerequisite: Biol. 407. Spring term, even years.

511. Advanced Plant Physiology (3) Physiology of plants including uptake of water and minerals, translocations, mineral nutrition, energy relations, respiration and catabolism. Prerequisite: Biol. 442. Fall term.

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*May be repeated for up to 6 credits.

512. Advanced Plant Physiology (3) Continuation of Biol. 511. Physiology of plants including photosynthesis, synthesis of cellular constituents, growth and development. Prerequisite: Biol. 442. Winter Term.

513. Biology Seminar (1 per term) Presentation and discussion of selected topics.

516. Ecological Plant Geography (3) Distribution of plant communities; environmental factors which influence their present distribution; geological-historical development of plant communities, their past distribution. Winter term, odd years.

517. Fish Behavior as Related to Aquatic Ecology (3) Receptor-effector systems, selection of habitat and the effects of behavioral interaction on population levels, growth and survival. Prerequisite: Biol. 452 or 462.

518. Special Problems (1-6) Prosecution of an assigned problem under the guidance of a staff member. Throughout the year as arranged. By appointment.

519. Zoogeography (3) The present distribution of world vertebrates, their evolution, and their patterns of dispersal in the past.

521. Medical and Industrial Mycology (3) Structure, life histories, classification, and techniques of study of the fungi pathogenic to man and of fungi important in industry. Fall term, odd years.

522. Myxomycetes, Phycomycetes, and Ascomycetes (4) Morphology, taxonomy, phylogeny, and life histories; identification and field work. Prerequisite: Biol. 418. Winter term, even years.

523. Basidiomycetes and Fungi Imperfecti (4) Morphology, taxonomy, phylogeny, and life histories. Prerequisite: Biol. 418. Spring term, even years.

524. Seminar in Genetics (1 per term)

526. (Geol. 526) Problems in Palynology (1-6) Systematics; paleoecological palynology; Paleozoic palynology; Mesozoic and Cenozoic palynology; Pleistocene vegetational history.

531. Bryology (3) Morphology, taxonomy, and ecology of liverworts, hornworts, and mosses; collection, preservation, culturing, and cytologic techniques. Spring term, even years.

533. Problems in Genetics (2-6) Problems to suit needs of individual students; conferences and laboratory work.

535. Morphology of the Tracheophyta Exclusive of Angiosperms (3) Origin, developmental tendencies, structure, and paleobotanical evidence. Winter term, odd years.

536. Morphology of Angiosperms (3) Floral origin and development, fertilization, embryogeny, seeds and fruit development. Prerequisite: Biol. 431.

538. Principles of Microscopic Histochemistry (2) Theoretical basis for the microscopic identification, localization, and quantitative analysis of chemical substances in tissues of organisms. Prerequisite: Biol. 405 or 437.

539. Analytical Histochemistry Laboratory (2-4) Application of histochemical techniques in the microscopic analysis of tissue lipids, proteins, carbohydrates, nucleic acids and proteins. Prerequisite or concurrent: Biol. 538.

540. Phycology (4) Comparative morphology, taxonomy, and ecology of fresh water and marine algae; culturing, collection, preservation techniques.

541. Comparative Physiology (3) Phylogenetic variation in the regulation of the internal environment of animals.

542. (Ent. 542) Systematics (3) Principles and methods of classification, phylogeny and speciation; taxonomic techniques, analysis of species; causal interpretation of animal diversity.

545. Ecosystem Dynamics (3) Analysis of the ecosystem concept based on consideration of ecosystem energetics, components, biotic and abiotic, function, and temporal relations. Prerequisite: Biol. 210.

546. Ecology of Populations and Communities (3) Ecological laws governing population growth and decline; reproductive and mortality rates; predation and composition as limiting factors. Fall term.

550. NEUROGENESIS (2) Embryonic and evolutionary development of the nervous system. Determination, differentiation, orientation, and specificity of growing and regenerating nerve cells. Prerequisite: Biol. 440.

557. (Sci.Ed. 557) WORKSHOP IN THE BIOLOGICAL SCIENCES (3) Projects designed for teachers of biology in the secondary schools. Summer term only.

571. (Phsio. 571) ANIMAL PHYSIOLOGY (2) Physiology of fluid transport mechanisms; examination of the distribution and regulation of body fluids, blood, and hemodynamics. Prerequisite: 3 credits in physiology.

572. (Phsio. 572) ANIMAL PHYSIOLOGY (2) Examination of nutrition, metabolism, and respiration as they relate to subcellular, cellular, and organ organizational levels of the whole animal. Prerequisite: 3 credits in physiology.

573. (Phsio. 573) ANIMAL PHYSIOLOGY (2) Detailed examination of animal reproduction, endocrine secretion and control, neural muscular activity, central nervous system correlates, and special senses. Prerequisite: 3 credits in physiology.

574. (Phsio. 574) ANIMAL PHYSIOLOGY LABORATORY (1-6) Selected problems using advanced physiological techniques to study transport mechanisms, circulation, excretion, respiration, metabolism, and neuroendocrines. Prerequisite: Biol. 473.

582. (Pty.Sc. 582, Psy. 582) RESEARCH IN ANIMAL BEHAVIOR (2-6 per term) Research in special areas of animal behavior involving field or laboratory work.

BIOPHYSICS (BPHYS)

WILLIAM D. TAYLOR, *Head of the Department*
618 Life Sciences Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Deering, Ginoza, Keith, Morgan, Person, Rake, Scheie, H. Schraer, Smyth, Snipes, Strother, Taylor, and Todd.

The major goal of this program is to train students for independent research and teaching in the interdisciplinary areas of biophysics and molecular biology. The students currently in the department have come from a variety of fields including physics, engineering, chemistry, biochemistry, and biology. Graduate students are expected to begin a research program during their first year of study. Personal attention is given each student by a faculty adviser to insure that the student's program is suited to his talents and is one that will permit him to earn a degree in a reasonable time. Course requirements are flexible and depend to a considerable extent on the student's research interests. The master's program is expected to take from 6 to 8 terms (4 terms per year), and the Ph.D. usually requires an additional 8 to 12 terms, including thesis research. Advancement to Ph.D. candidacy is decided on the basis of course and research performance in addition to a written examination. A comprehensive oral examination and thesis defense are integral parts of the Ph.D. program. Knowledge of a foreign language may be required depending on the area of research.

Research interests include theoretical biology, radiation biology, cell biology, molecular biology and genetics, electrophysiology, structure and function of biological membranes, molecular basis of learning and memory, developmental biology, biophysical chemistry, and instrumentation.

BIOPHYSICS (BPHYS)

410. SPECIAL TOPICS (1-6)
430. (Biol. 430) MOLECULAR BIOLOGY OF THE GENE (3)
473. INTRODUCTORY BIOPHYSICS (3)
474. MOLECULAR BIOPHYSICS I (3)
475. MOLECULAR BIOPHYSICS II (3)

501. SEMINAR IN CELL BIOLOGY (1) Discussion of current problems and ideas in cell biology with emphasis on reference to recent literature.

513. (Bioch. 513) BIOCHEMISTRY OF NUCLEIC ACIDS (2) Structure, reactions, synthesis, and biochemical properties of nucleic acids. Prerequisite: Bioch. 402.

577. MOLECULAR EVOLUTION AND DIFFERENTIATION (3) Evolution and differentiation studied by methods of denaturation and reassociation of DNA, RNA, and amino acid sequences. Current laboratory practice. Prerequisite: Bioch. 41 or 401 or Bphys. 473.

579. PHOTOBIOLOGY (2) Effects of visible and ultraviolet light on biological systems: energy absorption, transfer, utilization; photochemistry; metabolic and genetic responses; repair systems.

580. BIOPHYSICAL SCIENCE (3) Enzyme kinetics; thermodynamics of biological systems; molecular theory of reaction rates; structural aspects of biological reactions. Prerequisite: Bphys. 474 or Chem. 451.

581. RADIATION BIOPHYSICS (2) The action of ionizing radiation and of radioactive decay on biological systems: molecular and cellular aspects. Prerequisite: Bphys. 475.

582. BIOPHYSICS OF NUCLEIC ACIDS (3) Biophysical studies on the structure and function of the nucleic acids, particularly those of bacterial and viral origin.

585. BIOLOGICAL ULTRASTRUCTURE (4) The application of electron microscopy to the study of cell biology. Prerequisite: any of the following — Bphys. 473; Biol. 405, 437; Micrb. 401.

586. BIOLOGICAL MACROMOLECULES (3) Biopolymer characteristics; polymer statistics; size and shape determination; methods of separation; polyelectrolytes; optical and mechanical properties; denaturation; degradation; biosyntheses. Prerequisite: Bphys. 475 or Chem. 451.

587. ULTRACENTRIFUGATION (2) A laboratory course in ultracentrifugation techniques including applications to biophysical problems. Prerequisite: Bphys. 474.

588. PHYSIOLOGY OF NERVES, MUSCLES, AND SENSE ORGANS (2-6) Current literature of the function of nerves, muscles, and receptors. These subjects are considered individually in successive years. Prerequisite: a 400-level course in physiology, biophysics, or physiological psychology.

589. MAMMALIAN CELL CULTURE (3) Recent research in quantitative cell biology as studied with tissues and cells of higher organisms cultured *in vitro.* Prerequisite: Bioch. 401.

591. MICROSPECTROPHOTOMETRY (2) Principles of absorption spectroscopy; microspectrophotometer design; determination of cellular constituents using stained and unstained preparations; laboratory exercises. Prerequisite: graduate student standing.

595. ELECTRON SPIN RESONANCE SPECTROSCOPY (3) Experimental and theoretical aspects of electron spin resonance spectroscopy to provide ability for its application to biophysical problems. Prerequisite: basic knowledge of quantum mechanics and electromagnetic waves.

BOTANY (BOT)

JOSEPH G. O'MARA, *Head of the Department of Biology*
208 Life Sciences I Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Fergus, Grove, Grun, Hamilton, Hillson, Kneebone, Keener, Kovar, O'Mara, Pursell, Schein, Spackman, Therrien, Traverse, Wagner, Witham, and Wright.
Graduate Faculty: Associate Member Adams.

Botanical programs are offered in plant anatomy, cytology, ecology, genetics, morphology, mycology, physiology, and taxonomy. A student having a degree in science or in one of the biological sciences is eligible for admission. Entering graduate students should have had basic

courses in chemistry, mathematics, and physics. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Admission is restricted to students who have the baccalaureate degree in a biological science and who present a cumulative undergraduate average of at least 3.00. Each applicant must provide scores from the Graduate Record Examination, letters from two persons who are familiar with his academic competence, and a personal statement of his interests and objectives.

See also Genetics and Physiology.

NOTE: *For courses in Botany and related subjects see Biology.*

BUSINESS ADMINISTRATION (B A)

MAX D. RICHARDS, *In Charge of Graduate Programs in Business Administration*
102A Boucke Building

Degrees Conferred: Ph.D., M.S., M.B.A.

Graduate Faculty: Senior Members Babione, Beik, Bennett, Bither, Bradley, Carroll, Clewett, Cook, Coyle, Cramer, Ferrara, Fishburn, Greenlaw, Hammond, Hayya, Heitmann, Hottenstein, Kelley, Koot, Malcom, Mathews, Pashek, Philippatos, Philips, Richards, Rigby, Schrader, Shilling, Slocum, Spychalski, Susman, Waters, and Wilson.
Graduate Faculty: Associate Members Aggarwal, Bear, Carpenter, Curley, Daily, Daniels, Dolich, Francia, Hellriegel, Hrebiniak, Kochenberger, Koehler, Marlow, Melander, Millman, Nelson, Pfaffenberger, Phalan, Williams, and Wyman.

The M.B.A. is a professional program in business administration designed to prepare individuals for managerial positions in business and government and other nonprofit institutions. Individuals of all undergraduate disciplines — both business and nonbusiness — are encouraged to apply.

The M.B.A. program consists of two distinct portions: (1) 30 credits of foundation courses in accounting, statistics, calculus, finance, business law, economics, marketing, and management. These courses may be taken as part of an undergraduate curriculum or may be taken after admission to the program, and (2) 36 credits of advance graduate courses and a professional paper. The time required to complete the program varies from 12 to 21 months, depending upon undergraduate background.

The M.S. and Ph.D. programs with a major in business administration are designed for those interested primarily in research and teaching. The communication and foreign language requirement for the Ph.D. degree may be satisfied by a reading knowledge of two foreign languages or a reading, listening, and speaking knowledge of one language. The candidate may substitute quantitative analysis and/or behavioral science for the required reading knowledge in one or two languages.

For admission to the M.S. program, approximately 30 acceptable undergraduate credits in business administration, economics, and mathematics are required. An applicant may be admitted without foundation courses to be made up without degree credit. A student has an option of a thesis or a paper for the M.S. degree.

Applicants are evaluated for admission on the basis of academic potential and other factors giving evidence of high probability of completing the program. Data useful for evaluating academic potential include the applicant's experience, junior-senior average, ATGSB test scores, and academic recommendations. The best qualified applicants will be accepted up to the number of spaces that are available for new students.

Applicants to any of the graduate programs in business administration are required to take the Admission Test for Graduate Study in Business (ATGSB) given by the Educational Testing Service. Candidates are strongly urged to take the test at the earliest possible date. It is given at University Park and at numerous locations in most states and foreign countries in November, February, April, June, and August. For dates and locations, see the *Bulletin of Information,* Admission Test for Graduate Study in Business, Educational Testing Service, Princeton, N.J.

Applicants should read the bulletin carefully. All arrangements for taking the test are made directly with the Educational Testing Service.

This graduate program is accredited by the American Association of Collegiate Schools of Business.

ACCOUNTING (ACCTG)

401. ADVANCED ACCOUNTING (3)
403. AUDITING (3)
404. MANAGERIAL ACCOUNTING (3)
406. ADVANCED FEDERAL TAX ACCOUNTING (3)
409. MACHINE AND ELECTRONIC ACCOUNTING METHODS (3)

*398G. ACCELERATED ELEMENTARY ACCOUNTING (3) The theory and technique of financial and managerial accounting: preparation, analysis, and interpretation of financial statements. Open to graduate students only.

503. SEMINAR IN AUDITING (3) The attest function of independent public accountants, verification of financial statements; problems of evidence, independence, ethics, professional responsibilities. Prerequisite: Acctg. 403.

504. SEMINAR IN MANAGERIAL ACCOUNTING (3-6) Accounting and the managerial processes of planning, control, and decision making.

507. SEMINAR IN FINANCIAL ACCOUNTING (3) Theoretical basis of financial accounting.

508. CONTEMPORARY ISSUES IN ACCOUNTING (3) Selected problems of current interest to the accounting profession.

511. FINANCIAL AND MANAGERIAL ACCOUNTING (3) Fundamental financial and managerial accounting concepts and issues from the viewpoint of the report user.

512. FINANCIAL ACCOUNTING THEORY AND REPORTING PROBLEMS (3) Measurement and reporting of financial information for external purposes, with particular attention to current problems in asset and income measurement. Prerequisite: Acctg. 511.

515. DEVELOPMENT OF ACCOUNTING THOUGHT (3) Development of accounting thought from ancient civilizations to the present.

BUSINESS ADMINISTRATION (B A)

499. FOREIGN STUDY IN BUSINESS ADMINISTRATION (2-6)

503. SEMINAR IN PUBLIC UTILITIES (3)

537. (Cmp.Sc. 537) MANAGEMENT INFORMATION SYSTEMS DESIGN (3) Cost, value, and technical considerations in analysis and design of information systems whose purposes are to aid decision making in organizations.

538. INFORMATION SYSTEMS FOR PLANNING AND CONTROL (3) Analysis of information requirements for planning, decision making and performance measurement in organizations.

539. SEMINAR IN MANAGEMENT INFORMATION SYSTEMS (3) Special topics selected from contemporary issues in management information systems.

540. BUSINESS ADMINISTRATION THEORY AND PRACTICE (3) An integrating course primarily for M.S. students using cases requiring analysis involving interrelated aspects of business administration and control.

541. READINGS IN BUSINESS ADMINISTRATION (6) Critical study and discussion of important topics in business administration.

550. BEHAVIORAL SCIENCE IN BUSINESS (3) Application of behavioral science concepts and analytical methods to problems in business organizations. Analysis of administrative behavior and decision making.

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*No graduate credit is given for this course.

552. BUSINESS RESEARCH METHODS (3) Research methods applicable to business problems with emphasis on means of obtaining data and the logic underlying research design.

555. BUSINESS AND SOCIETY (3) Evolution of the business organization and the changing framework of its operations, responsibilities, and social control.

574. BUSINESS RESEARCH (1-3) A project paper, comparable in quality and scope of work to a graduate thesis, on problems of a company. Prerequisite: 15 credits of 400 and 500 courses in business administration.

577. ADMINISTRATIVE INTEGRATION (3) An analysis of coordination of the functional areas of business in relation to overall company objectives. Prerequisite: 15 credits of 400 and 500 courses in business administration.

BUSINESS LAW (B LAW)

*398G. ACCELERATED BUSINESS LAW (3) Social control through law: courts; policies underlying individual rights; negotiable and nonnegotiable contractual rights in society. Open to graduate students only.

BUSINESS LOGISTICS (B LOG)

412. TRANSPORT PLANNING ANALYSIS (3)
420. URBAN TRANSPORTATION (3)
430. TRANSPORT PROBLEMS (3)
440. LOGISTICS SYSTEMS ANALYSIS (3)

538. LOGISTICS SYSTEMS MANAGEMENT (3) Control of the movement of goods; coordination of supply and demand in creation and maximization of time and place utility.

540. TRANSPORT POLICY (3) Role of transport in the economy. Transport systems elements, development, cost and pricing characteristics. Public control and public policies.

541. SOCIOECONOMIC ANALYSIS IN TRANSPORTATION (3) Role of transport in social and economic activity. Planning and coordination of transport systems. Designed for the Traffic Engineering program.

565. SEMINAR IN BUSINESS LOGISTICS (3-6)

FINANCE (FIN)

406. SECURITY ANALYSIS AND PORTFOLIO MANAGEMENT (3)
408. FINANCIAL MARKETS (3)
410. SPECULATIVE MARKETS (3)

*398G. ACCELERATED FINANCIAL MANAGEMENT (3) Financial planning and forecasting; management of working capital, capital budgeting, and dividend policy; capital structure and valuation. Open to graduate students only.

504. PROBLEMS IN FINANCE (3-6) Planned individual projects involving library, laboratory, or field work.

506. PORTFOLIO THEORY AND POLICY (3) Rigorous examination and analysis of asset-holder behavior under conditions of risk and uncertainty.

508. ANALYSIS OF FINANCIAL MARKETS (3) Analysis of factors affecting price determination in financial markets.

510. CONTEMPORARY ISSUES IN FINANCIAL INSTITUTIONS (3) Critical investigation of problems of current interest in the market structure and internal operations of financial institutions.

531. FINANCIAL MANAGEMENT (3) An intensive examination of techniques available to aid the financial manager in decision making.

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*No graduate credit is given for this course.

532. NORMATIVE MODELS IN BUSINESS FINANCE (3) Application of advanced analytical techniques and models to financial decision making under uncertainty.

541. FINANCIAL THEORY (3) A theoretical analysis of the elements of finance.

561. SEMINAR IN FINANCE (3-6) Comparative analysis of research in the theories of finance; relationships to business management practices.

INSURANCE (INS)

400. ESTATE PLANNING (3)

500. INSURANCE THEORY AND PRACTICE (3) Insurance as an institution, a technique, a legal contract; its environment as a regulated industry.

504. PROBLEMS IN INSURANCE (3) Planned individual projects involving library, laboratory, or field work.

510. RISK MANAGEMENT (3) Analysis of managerial problems and responsibility of risk analysis, removal or reduction, and allocation of corporate resources to provide indemnity.

520. SEMINAR IN INSURANCE (3-6) Selected topics on advanced aspects of risk management with emphasis on the insurance technique for treating hazards.

INTERNATIONAL BUSINESS (I B)

501. THE INTERNATIONAL ENVIRONMENT (3) Conceptual approach analyzing and predicting influences of social, political, and economic norms and values upon diverse societies' managerial decision making.

502. INTERNATIONAL BUSINESS MACRO THEORY AND POLICY I (3) International economic trade and monetary tools are applied to current national policy issues to determine effects on international business operations. Prerequisite: Econ. 333.

503. INTERNATIONAL BUSINESS MICRO THEORY AND POLICY I (3) Analysis of the internal operations of multinational firms; design of optimal strategies of operation under varying environmental conditions.

504. SEMINAR IN INTERNATIONAL BUSINESS (3-6) Seminar in techniques applied to selected topics; market structures; capital budgeting, investment; comparisons of foreign norms and values; multinational organization characteristics.

MANAGEMENT (MGMT)

410. OPERATIONS PLANNING AND CONTROL (3)
420. MANAGEMENT OF PERSONNEL SYSTEMS (3)
422. ADVANCED ORGANIZATION THEORY (3)
430. ADMINISTRATIVE MANAGEMENT (3)
432. SIMULATION OF MANAGEMENT SYSTEMS (3)
435. CASES IN PUBLIC RELATIONS (3)

*398G. ACCELERATED BUSINESS MANAGEMENT (3) The concepts of management and its decision processes including special attention to operations management.

510. OPERATIONS MANAGEMENT (3) Integration and application of decision making to operational and policy problems within the business firm.

515. DESIGN OF OPERATION OUTPUT SYSTEMS (3) Examination of research-based findings in operations management with a focus on the design and reliability of production systems.

516. OPERATIONS PLANNING AND CONTROL (3) Examination of research-based findings in operations management. The focus is on the operation and control of production systems.

517. CONCEPTUAL BASES OF SOCIOTECHNICAL SYSTEMS (3) Integrates behavioral science and operations management in sociotechnical framework. Design of sociotechnical systems.

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*No graduate credit is given for this course.

518. MANAGEMENT OF INVENTORY SYSTEMS. (3) Analysis of business organizations as integrated inventory systems. Inventory theory and model building as tools for management decision making. Prerequisite: Q.B.A. 561 or Mgmt. 510 or I.E. 509.

519. SEMINAR IN OPERATIONS MANAGEMENT (3-6)

520. ORGANIZATION THEORY (3) Theoretical and operating structures in formal business organizations; relation of formal organization to informal groups and to individuals.

521. SEMINAR IN ORGANIZATIONAL BEHAVIOR (3) Examination of research-based findings on organizational behavior. Methodological techniques for studying human behavior in formal organizations.

523. ORGANIZATIONAL CHANGE: THEORY AND PRACTICE (3) Analysis of research, theory and practice in dynamics of organizational change. Research literature reviewed for evaluation of concepts and methods.

524. INTERPERSONAL RELATIONS IN ORGANIZATIONS (3) Development of skills and sensitivity for dealing with interpersonal relationships in complex organizations. Prerequisite: B.A. 550.

531. MANAGEMENT INFORMATION SYSTEMS (3) Information system theories and methods applied to administrative structures and management decisions in organizations.

540. PERSONNEL MANAGEMENT (3) Theoretical constructs underlying personnel administration; analysis of professional personnel functions in business firms.

570. SEMINAR IN MANAGEMENT (3-6) Comparative analysis of research in the theories of the administrative sciences; relationships to business management practices.

MARKETING (MKTG)

424. MARKETING RESEARCH (3)
435. MARKETING AND PUBLIC POLICY (3)

*398G. ACCELERATED MARKETING MANAGEMENT (3) Analyses of customer and market behavior, marketing systems, and competitive strategies; programming product, pricing, distribution, and promotion. Open to graduate students only.

500. MARKETING MANAGEMENT (3) Analysis of management's marketing problems including market analyses, pricing, channel of distribution, promotion, competition, product strategies, and marketing research.

510. PLANNING MARKET STRATEGY AND PROGRAMS (3) Development of marketing strategy for the firm and design of integrated product-service, promotion, and distribution programs utilizing systems analysis.

520. QUANTITATIVE ANALYSIS FOR MARKETING DECISIONS (3) Sales forecasting, new product proposals, media selection, and market testing analyzed using statistical and decision theory and other mathematical techniques.

530. CONSUMER AND MARKET BEHAVIOR (3) Buying behavior: concepts from the behavioral sciences, including utility, culture, life cycle, personality, attitudes, and learning.

540. MARKETING AND SOCIETY (3) Marketing problems of society, domestic and regional marketing systems; governmental policies toward marketing; social performance of marketing.

544. MARKETING THEORY (3) The development of marketing concepts, behavioral and other marketing theories; public policy and the role of marketing in societies.

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*No graduate credit is given for this course.

QUANTITATIVE BUSINESS ANALYSIS (Q B A)

403. Intermediate Business Statistics (3)
404. Sampling in Business Operations and Research (3)
451. Analytical Methods in Business (3)
452. Analytical Methods in Business (3)
461. Probabilistic Models in Business (3)
490. Special Topics (3-6)

*398G. Accelerated Business Statistics (3) Basic characteristics of univariate and bivariate distributions, probability theory, introduction to estimation, tests of hypotheses, and time series analysis. Open to graduate students only.

500. Seminar in Business Statistics (3-6)

501. Advanced Business Statistics (3)

510. Statistics in Business Research (3) Statistical principles and procedures essential to the interpretation and performance of research in business administration. Prerequisite: common requirements of M.B.A. program.

521. Quantitative Analysis for Business Decisions (3) Construction and use of quantitative models in business decision making. Prerequisite: common requirements of M.B.A. program.

527. Statistical Decision Theory (3) A systematic survey and analysis of the concepts and methods of Bayesian statistical decision theory.

532. Management Systems Simulation (3) Application of computer simulation to the analysis and design of management decision systems. Design of simulation experiments in business research. Prerequisite: 3 credits of computer programming.

550. Seminar in Mathematical Programming (3-6) Intensive treatment of theory and computational algorithms of mathematical programming; emphasis on operational application to complex management and business problems. Prerequisite: I.E. 510.

561. Stochastic Models for Management Decisions (3) Introduction to stochastic processes in business organizations. Application to stochastic models to the conceptualization, analysis, and solution of management problems. Prerequisite: Math. (Stat.) 427.

570. Management Science: Implementation and Control (3) Development and application of management science models. Model formulation and specification, sensitivity analysis, problems encountered in implementation and control.

REAL ESTATE (R EST)

400. Urban Land Utilization (3)

CERAMIC SCIENCE (CERSC)

GUY E. RINDONE, *In Charge of Graduate Programs in Ceramic Science*
201 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Bradt, Hummel, McKinstry, Newnham, Rindone, Stubican, and Williamson.
Graduate Faculty: Associate Members Biggers and Tressler.

This program is one of the options in which a graduate student in the Department of Material Sciences can receive an advanced degree. In view of the wide field covered by ceramic science,

*No graduate credit is given for this course.

the graduate courses may be selected with a bias toward physical ceramics, chemical ceramics, or glass science.

The communication and foreign language requirement may be satisfied by (1) examinations in two languages — French examination administered by the ceramic science faculty and a second language examination by the appropriate language department or (2) examination in one foreign language *and* either 6 credits of computer science or 6 credits of statistics, or 3 credits of computer science and 3 credits of statistics.

Special facilities exist for research in the areas of electroceramics, rheology, phase equilibria, solid state synthesis, mechanical properties, ferrite and ferroelectric studies, glass science, and high temperature reaction kinetics. Suitable preparation for graduate study in this program may be found in one of the materials sciences such as ceramics or metallurgy, in engineering fields such as chemical or mechanical engineering, in the basic physical sciences, or in the earth sciences.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

CERAMIC SCIENCE (CERSC)

400. (Min. 400) Nonmetallic Crystal Chemistry (2-3) *Mr. Newnham*
402. Principles of Ceramic Engineering (3) *Mr. Williamson*
404. Ceramic Seminar (1) *Mr. Hummel*
405. Ceramic Research and Design (1)
406. Rheology and Fluid Properties of Ceramic Systems (2) *Mr. Williamson*
407. Ceramic Materials Laboratory (2) *Mr Williamson*
408. Heat Treatment of Ceramic Materials (1) *Messrs. McKinstry and Tressler*
409. Heat Treatment Laboratory (2) *Messrs. McKinstry and Tressler*
410. Phase Relations in Ceramic Systems (3) *Mr. Hummel*
411. Principles of Ceramic Processes (2) *Mr. Stubican*
414. Mechanical Properties of Ceramics (3) *Mr. Bradt*
415. Principles of Glass Technology (3-4) *Mr. Rindone*
420. Refractories (2-3) *Mr. Stubican*
425. Ceramic Research and Design (2)
430. Electroceramics (2) *Mr. Biggers*
431. Electroceramics Laboratory (1) *Mr. Biggers*

500. Seminar in Ceramic Science (1-2 per term) Current developments in ceramic science and related fields. Required of all graduate students in ceramic science. *Staff*

501. Surface Behavior of Ceramic Materials (2-4) Surface chemistry of ceramics. Rheology of ceramic powders, suspensions and pastes. *Mr. Williamson*

503. Use of Phase Equilibria Data in Ceramic Science (2-5) Phase equilibria in unary, binary, ternary, and other systems; applications in product development and in understanding behavior of ceramic materials. *Mr. Hummel*

504. Solid State Reactions in Ceramic Systems (2) Thermodynamic, kinetic, and structural study of reactions and of equilibrium in ceramic systems. Prerequisites: Chem. 451, 452. *Mr. Stubican*

505. Phase Transition in Solids (2) Phase transitions will be studied in detail with respect to the crystal structure, free energy, and physical properties. *Mr. McKinstry*

506. Mechanical Properties of Ceramics (3) Theoretical consideration of internal stresses, dislocations and dislocation processes, and macro- and microstructural variables on the mechanical properties of ceramics. Prerequisite: Cer.Sc. 414. *Mr. Bradt*

507. Thermal Properties of Ceramic Materials (2-3) Heat capacity, heat of fusion, thermal conductivity, and thermal expansion in relation to macroscopic measurements and basic atomic concepts applied to ceramic materials. *Mr. Stubican*

508. Dielectric and Magnetic Properties of Ceramic Materials (2-3) Preparation and properties of ceramic semiconductors, dielectrics, and magnetic materials. *Mr. Newnham*

509. Composite Materials (3) Manufacturing processes, atomic and molecular background, and topological relationships of macro- and microstructure to the physical properties of composites. *Messrs. Bradt and Tressler*

510. Seminar in Glass Technology (1-2 per term) Current developments in glass technology and related fields. *Mr. Rindone*

511. The Constitution of Glass (2-3 per term) Historical and current concepts of the atomic structure of glass; relationship of structure to chemical and physical properties *Mr. Rindone*

512. Selected Properties of the Vitreous State (2-3 per term) Measurement and interpretation of such properties as: radiation effects; viscoelasticity; electrical, mechanical, optical, and thermal properties. *Mr. Rindone*

515. Special Problems in Ceramic Science (1-6 per term) Advanced individual study on a problem in ceramics.

516. Selected Topics in Ceramic Science (1-3 per term) Intensive group study of special topics.

530. (Min. 530) Structure, Properties, and Occurrence of Clay Minerals (2-5) Structure analysis and identification of clay minerals; mineral transformation and behavior; occurrence, genesis, and petrography of fine-grained sediments. *Mr. Brindley*

Note: *Courses in the use of X-ray diffraction, electron microscopy, and the electron microprobe in ceramic science studies are listed under Materials Science.*

CHEMICAL ENGINEERING (CH E)

Lee C. Eagleton, *Head of the Department*
160 Merrell R. Fenske Laboratory

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Braun, Daubert, Eagleton, Engel, Jones, Kabel, Klaus, and McCormick.
Graduate Faculty: Associate Members Barton, Danner, Duda, Notter, and Ultman.

Course offerings or research facilities are available in the following areas: phase equilibria, thermodynamics, kinetics, mass transfer, transport phenomena, unit operations, unit processes, bioengineering, applied chemistry and petrochemistry, petroleum technology, rheology, and lubrication. A foreign language is not required for the Ph.D. degree.

To be admitted, a student should be a graduate of an accredited major in chemical engineering or the equivalent. Graduates of other accredited engineering or physical science majors may be admitted but will be required to make up certain undergraduate deficiencies without graduate credit. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

CHEMICAL ENGINEERING (CH E)

401. Chemical Process Engineering (4)
404. Chemical Engineering Economics (3)
406. Chemical Engineering Problems (3)
408. Chemical Engineering Laboratory II (2)
413. Mass Transfer Operations (3)
414. Kinetics and Industrial Chemistry (4)

415. Mathematical Modeling in Chemical Engineering (3)
416. Techniques of Process Design (3)
420. Cryogenic Engineering (3)
422. Modern Petroleum Technology — Processes and Products (3)
430. Nuclear Chemical Engineering (3)
431. Advanced Industrial Chemistry Applications (3)
435. Chemical Reaction Kinetics (2)
440. Chemical Engineering Materials (3)
445. Projects in Chemical Engineering (1-6)
446. Introduction to Transport Phenomena (3)
448. Advanced Mass Transfer Operations (3)
450. Process Dynamics (3)
453. Thermodynamics for Chemical Engineers (3)
455. Chemical Reactor Design (3)
460. Chemical Engineering (4)

500. Seminar in Chemical Engineering (1) Required of all graduate students.

507. Simulation and Modeling (3) Synthesis of subsystem and system models emphasizing the generality of the principles for application to diverse physical and chemical processes.

508. Principles of Industrial Organic Chemistry (3) Principles and practices of modern conversion processes in the manufacture of organic chemicals. Prerequisites: Chem. 31, 452. *Mr. Jones*

509. Heat Transfer Applications (3) Advanced treatment of steady-state and transient conduction, convection, and radiation, with emphasis on numerical methods and design techniques. Prerequisite: an undergraduate course in heat transfer. *Mr. Daubert*

515. Distillation (3) Commercial distillation, equilibrium diagrams, vapor composition, stills and rectifying and stripping columns.

516. Methods of Process Design (3) Survey of mathematical techniques of chemical process design with emphasis on economic choice and optimal decision making. *Mr. Engel*

520. Extraction Processes (3) Equilibrium extraction data and phase contacting and settling related to equipment design.

521. Transport Phenomena (3) Momentum, heat, and mass transfer in boundary layers and turbulent fluids; ideal potential flow; unsteady state and coupled transport.

522. Special Topics in Transport Phenomena (3) Intensive group study and discussion of current problems and techniques in transport processes. Prerequisite: Ch.E.521.

524. Chemical Engineering, Application of Thermodynamics (3) Elements of thermochemistry and thermodynamics of greatest importance in chemical engineering.

535. Chemical Reaction Engineering (3) Optimal design of batch and continuous chemical reactors and reactor batteries; effect of mixing on reactor operation. Prerequisite: Ch.E. 435. *Messrs. Engel and Kabel*

CHEMISTRY (CHEM)

JOSEPH A. DIXON, *Head of the Department*
152 Davey Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Allcock, Ascah, Benkovic, Bernheim, Deno, Dixon, Fritz, Gold, Haas, Hamilton, Hayes, Heicklen, Hisatsune, Horrocks, Jackman, Jordan, Jurs, Lampe, Lowe, Miller, Olofson, Richey, Rosenblatt, Shamma, Skell, Steele, Wartik, and Zook.
Graduate Faculty: Associate Members Crawford, Goncalves, Lotz, Riehl, Risby, Seeley, and Villafranca.

Students may specialize in analytical, inorganic, organic, or physical chemistry. The general facilities are excellent, and the computer, cryogenic, radiochemical, and spectroscopy laboratories provide unusual research opportunities. Distinguished visiting scholars conduct informal discussion each Thursday at a departmental colloquium. The department requires a knowledge of French, German, Japanese, or Russian as a condition for awarding either the M.S. or Ph.D. degree. Candidates who have taken and passed two undergraduate courses in French, German, Japanese, or Russian will be certified as having completed the communication and foreign language requirement. For the M.S. degree the student has the option of writing a thesis or a paper.

For admission, at least integral calculus plus one year's work in general physics, organic chemistry, physical chemistry, and either analytical or inorganic chemistry is normally required. Students who have appropriate course backgrounds and who present a 2.50 average in all undergraduate courses in chemistry, physics, and mathematics will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Prior to scheduling their first term programs, new students will take examinations in the areas of analytical, inorganic, organic, and physical chemistry. The information obtained from these tests will assist both the student and his adviser in making up a program best suited to the student's needs. These examinations are normally given just prior to the regular registration period.

CHEMISTRY (CHEM)

400. CHEMICAL LITERATURE (1)
401. SEMINAR (1)
405. NUCLEAR AND RADIOCHEMISTRY (3)
408. (Cmp.Sc. 408) COMPUTER APPLICATIONS IN CHEMISTRY (3)
410. INORGANIC CHEMISTRY (2)
411. ADVANCED INORGANIC CHEMISTRY (2)
412. EXPERIMENTAL INORGANIC CHEMISTRY (2)
423. ADVANCED ANALYTICAL CHEMISTRY (3)
424. ADVANCED ANALYTICAL LABORATORY (2)
426. CHEMICAL INSTRUMENTATION (3)
431. ADVANCED ORGANIC CHEMISTRY LABORATORY (3)
435. ADVANCED ORGANIC CHEMISTRY LABORATORY (3)
439. STRUCTURAL ANALYSIS OF ORGANIC COMPOUNDS (3)
448. COLLOID CHEMISTRY (3)
*451-452. PHYSICAL CHEMISTRY (3 each)
453. ADVANCED PHYSICAL CHEMISTRY (3)
454. ADVANCED PHYSICAL CHEMISTRY (3)
455. PHYSICAL CHEMISTRY OF HIGH POLYMERS (3)
*457. EXPERIMENTAL PHYSICAL CHEMISTRY (2)
*458. EXPERIMENTAL PHYSICAL CHEMISTRY (1)
489. INTRODUCTION TO CHEMICAL RESEARCH (1-10)
493. SELECTED TOPICS IN CHEMISTRY FOR TEACHERS (3-9)

*Graduate credit not allowed for students majoring in chemistry or chemical engineering.

500. SEMINAR IN CHEMISTRY (1 per term)

516-517. INORGANIC CHEMISTRY (3 each) Systematic treatment of inorganic chemistry in terms of modern concepts.

518. SPECIAL TOPICS IN INORGANIC CHEMISTRY (3 per term) Modern developments in specialized fields.

525. ANALYTICAL PROCESSES (3) Theoretical foundations and contemporary developments.

526. MODERN INSTRUMENTAL ANALYSIS (3)

527. SPECIAL TOPICS IN ANALYTICAL CHEMISTRY (2-12)

531. SPECIAL TOPICS IN ORGANIC CHEMISTRY (3-12) Prerequisite: Chem. 536.

534. CHEMICAL APPLICATIONS OF QUANTUM THEORY (3) A development of Molecular Orbital Theory up to the level of present-day usage in organic and inorganic chemistry.

535-536. ORGANIC REACTION MECHANISMS I AND II (3 each) Reaction mechanisms and their determination by kinetic and nonkinetic methods. Reactive intermediates. Prerequisite: Chem. 439.

537. SYNTHESIS IN ORGANIC CHEMISTRY (3) Theory and methods of directed syntheses, including stereospecific and stereoselective schemes; biologically inspired syntheses. Prerequisite: Chem. 536.

544. CHEMICAL THERMODYNAMICS (3) Development of thermodynamic theory with special reference to common physical changes and chemical reactions. Prerequisite: Chem. 452.

545. STATISTICAL THERMODYNAMICS (3) The calculation of thermodynamic properties from molecular and spectroscopic data. Prerequisites: Chem. 544, 565.

560. TOPICS IN PHYSICAL CHEMISTRY (2-6)

563. CHEMICAL KINETICS (3) Theory and measurement of the rates of chemical reactions, molecular dynamics, and mechanisms of chemical reactions. Prerequisites: Chem. 544, 565.

565. ATOMIC AND MOLECULAR STRUCTURE (3) Introduction to modern theoretical chemistry, spectroscopy, and structure of atoms and molecules.

566. QUANTUM CHEMISTRY (3) Theoretical calculations of electronic properties of atoms and molecules. Prerequisite: Chem. 565. Prerequisite or concurrent: Math. 555.

567. QUANTUM CHEMISTRY (3) A continuation of Chem. 566, including problems and theories of electron correlation. Prerequisite: Chem. 566.

571. POLYMER CHEMISTRY (3) The synthesis, reactions, and structure determination of high polymers.

589. STUDIES IN CHEMISTRY (1-9) Theoretical research, experimental research, or a critical survey of the literature in an area of chemistry.

CIVIL ENGINEERING (C E)

RAYMOND E. UNTRAUER, *Head of the Department*
212 Sackett Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Barnoff, Cady, Gotolski, Larson, McDonnell, Nesbitt, Reich, Taylor, Untrauer, and Unz.
Graduate Faculty: Associate Members Aron, Davinroy, Long, McClure, Miller, Mozingo, Rachford, Rea, Reed, Regan, Weeden, West, and Willenbrock.

Students may specialize in structures, hydraulics, hydrology, transportation engineering, traffic engineering, materials, construction, soils, and sanitary engineering, or combinations of these.

Relevant courses are offered both by the Department of Civil Engineering and by other departments of the University.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by a reading knowledge of an acceptable foreign language and proficiency in English. A thesis is required for the M.S. degree. An engineering report is required for the M.Eng. degree.

Candidates normally should be graduates in engineering from an accredited college of engineering. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

See also Sanitary Engineering.

CIVIL ENGINEERING (C E)

200. SEMINAR (1-3)
201. CIVIL ENGINEERING PROJECTS (2-12)
221. HIGHWAY ENGINEERING (3)
222. TRANSPORTATION ENGINEERING (3)
223. TRAFFIC CHARACTERISTICS AND MEASUREMENTS (3)
224. CIVIL ENGINEERING MATERIALS (3)
231. CIVIL ENGINEERING CONSTRUCTION (3)
246. ADVANCED SOIL MECHANICS (3)
247. STRUCTURAL ANALYSIS BY MATRIX METHODS (3)
248. ADVANCED STRUCTURAL DESIGN (3)
251. ADVANCED HYDROLOGY (3)
252. WATER RESOURCES AND COMPUTATIONS (4)
262. OPEN CHANNEL HYDRAULICS (3)
265. RIVER AND WATERWAYS ENGINEERING (3)
271. ENVIRONMENTAL SANITATION (3)
272. WATER POLLUTION CONTROL (3)
276. SOLID WASTE MANAGEMENT (3)

200. SEMINAR IN CIVIL ENGINEERING (1-6) Reports on researches and special topics. Course may be continued in subsequent terms.

201. CIVIL ENGINEERING PROJECTS (3-10) Investigation or design projects in structures, transportation, hydraulics, or civil engineering materials.

211. ENGINEERING SOIL CHARACTERISTICS (3) Physical and chemical factors in soil which influence their engineering properties of strength, deformation, permeability, and soil stabilization.

212. APPLIED SOIL MECHANICS (2-5) Soil classification by type of clay minerals and profile development; aerial photographic interpretation of soils and applications to site selection for dams, highways, and airports.

213. SOIL EXPLORATION AND ANALYSIS (3) Laboratory evaluation of parameters used in modern soil mechanics. Involved techniques of soil testing, test limitations, sampling influences, technical reports.

219. TRAFFIC ADMINISTRATION AND FINANCE (2) Organization and administration of traffic engineering at various levels of government; leaders in the highway transportation field are guest lecturers.

220. PAVEMENT DESIGN (3) Fundamental principles; properties of pavement components; design tests; design of flexible pavements; design of rigid pavements; pavement evaluation and strengthening.

221. TECHNIQUES OF TRANSPORTATION ANALYSIS (2-4) Transportation functions, travel patterns, basic analytical methods in the planning content.

222. HIGHWAY OPERATIONS (2) Theory and application of traffic controls, including functional operations of traffic signals, systems, and networks; the design of highway lighting.

523. Urban Transportation Planning, Technology, Policy, and Administration (2-4) Characteristics of urban areas, the urban transportation planning process, present and future urban transportation systems, urban transportation policy and administration.

524. Advanced problems in Civil Engineering Materials (2-6) Study, in the literature and by laboratory investigation, of selected topics on field-controlled civil engineering materials. Prerequisite: C.E. 424.

525. Airport Planning and Design (3) Aircraft characteristics; aeronautical demand; site selection; airport configuration; capacity analysis; design of landing and terminal areas.

526. Transportation Design-Impacts Interaction (3) Transportation facilities with specific consideration of impact of such facilities on nontransport considerations; interaction of design criteria and impacts.

527. Theory of Traffic Flow (3) Phenomenon of vehicular traffic flow; flow density relationships; spacing; gap counting; delays; problems involving interrupted flow; multiflow routes.

528. Queuing Models in Transportation (3) Arrival patterns; the service mechanism, queue discipline; delays; busy period; queue length. Applications to pedestrian and vehicle delay. Prerequisite: Stat. 418.

529. Highway Geometric Design (3) Principles of road and parking terminal design with emphasis on operations; highway planning related to alternate solutions of design problems. Prerequisites: C.E. 423, 522.

533. Ultimate and Plastic Design Methods (3) Plastic design of steel structures. Limit design of concrete structures. Ultimate theories applied to plate and slab problems.

537. Matrix Method of Structural Analysis (3) Analysis of structures using advanced matrix techniques, transformation of matrices, energy concepts, iterative solutions, applications to linear and nonlinear structures. Prerequisite: C.E. 447.

539. Approximate Methods of Structural Analysis (3) Newmark's method, finite difference method, and finite element method applied to problems in structural and soil engineering.

540. Advanced Structural Analysis I (3) Analysis of continuous trusses and beams, frames, arches, grids, curved beams, suspension systems and space frames by classical methods.

541. Advanced Structural Analysis II (3) Analysis of continuous beams and frames, grids, slabs, shells and three-dimensional structural and soils problems by finite element methods.

544. Advanced Design of Concrete Structures (3) Concrete working stress, ultimate strength, limit design; test behavior of beams, slabs, columns; simple and continuous prestressed concrete members.

545. Advanced Structural Design (2-4) Steel, aluminum members; flexible connections; composite, hybrid, prestressed beams; tension-field beams; buckling; plastic analysis, design; test data; timber design. Prerequisite: C.E. 41.

546. Thin Concrete Structures (3) Design of thin concrete structures including slabs, folded plates, and shells.

548. Structural Design for Dynamic Loads (3) Dynamic behavior of structural systems of one and more degrees of freedom; earthquake, blast-resistant analysis, and design of structures.

549. Long Span Structures (3) Analysis and design of suspension bridges, cable roofs, and arch-type structures.

550. Engineering Construction Management (2-4) Management fundamentals for construction contracting; organization, project planning, scheduling and control, bonding and insurance, labor legislation and regulation, cost and control. Prerequisite: C.E. 431.

551. Hydrologic Investigations (2-8) Application of hydrologic principles and techniques to a specific project.

552. HYDROLOGIC PROCESSES AND CYBERNETICS (3) Application of cybernetic concepts in electronic computer simulation of the hydrologic process-components: infiltration, precipitation, evapotranspiration, and overland flow. Prerequisite: C.E. 51 or 452.

553. PLANNING MULTIPURPOSE HYDROLOGIC SYSTEMS (3) Study of multipurpose hydrologic schemes within a social, economical, and political framework. Prerequisite: C.E. 451 or 452.

554. URBAN HYDROLOGY (3) Several hydrograph methods. Design storm and IUH application; airport drainage; flood planes; impact of urbanization upon groundwater and sediment. Prerequisite: C.E. 451 or 452.

560. DIMENSIONAL ANALYSIS AND THEORY OF MODELS (3) Principles of dimensional analysis and similitude with engineering applications.

564. HYDRAULIC ENGINEERING DESIGN (2-8) Design and analysis of selected units of a typical hydraulic engineering project.

565. TRANSPORTATION OF SOLIDS BY FLUIDS (2-5) Fundamentals of the flow of solids in open and closed conduits; e.g., suspended load and bed load in rivers, slurries and pulp stocks in pipes.

571. WATER TREATMENT THEORY (3) Theory of modern methods of conditioning water for municipal and industrial use. Prerequisite: C.E. 472.

572. WASTE TREATMENT THEORY (3) Theory of modern methods of waste treatment. Prerequisite: C.E. 472.

573. PROBLEMS IN ENVIRONMENTAL POLLUTION CONTROL (3-9) Investigations, analyses, and reports on current topics in environmental pollution control.

574. LABORATORY ANALYSES IN WATER QUALITY CONTROL (3) Experiments illustrating current chemical and biochemical methods of water and waste treatment and analytical methods used in research and control.

575. ADVANCED INDUSTRIAL WASTE TREATMENT (3) Techniques of industrial waste treatment; attendant stream pollution and stream self-purification factors. Prerequisite: C.E. 472 or 572.

576. WATER TREATMENT PLANT DESIGN (1-6) Design of works for treatment of water for municipal and industrial use. Prerequisite: C.E. 71.

577. WASTE TREATMENT PLANT DESIGN (1-6) Design of works for the treatment of municipal or industrial wastes. Prerequisite: C.E. 71.

579. (Micrb. 529) AQUATIC MICROBIOLOGY (3) Ecology and physiology of microorganisms of inland waters, estuaries, and oceans; microbiology of wastewater treatment. Prerequisite: introductory microbiology.

580. STREAM AND ESTUARINE ANALYSIS (3) Quantitative assessment of advection, reaction, and dispersion processes in polluted waters; reaeration theory; eutrophic systems; analog simulation. Prerequisite: C.E. 472.

CLASSICS (CLASS)

ANTHONY J. PODLECKI, *Head of the Department*
104 Carnegie Building

Degree Conferred: M.A.

Graduate Faculty: Senior Members Carrubba and Podlecki.
Graduate Faculty: Associate Member Donlan.

Programs leading to the master's degree in this major offer opportunities for specialization in either Latin or Greek, or a combination of both. The minimum requirement for admission to either program will normally be 18 undergraduate credits in either language. Provision is made,

however, for admission with limited deficiencies. Candidates may either submit a thesis or schedule 6 additional credits in 500-level courses in the major field.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

GREEK (GREEK)

401. Introductory Readings in Greek Literature (3)
420. The Greek Historians (3)
421. Greek Tragedy (3)
422. Greek Comedy (3)
425. Homer (3)
430. The Greek Philosophers (3-9)
431. Plato (3)
450 Topics in Greek Literature (3-6)
451. (Ling. 451) History of the Greek Language (3)
489. Studies in Greek Literature (1-6)

502. Greek and Latin Epigraphy (3) Study of the techniques of epigraphical research; the value of inscriptions for Greek and Roman history and private antiquities.

507. Problems in Greek Archaeology (3-9)

509. Greek Seminar (3-9)

517. Greek Research (1-6) Prosecution of an assigned problem under the guidance of a member of the department.

LATIN (LATIN)

401. Introductory Reading in Latin Literature (3)
420. The Latin Historians (3)
425. Latin Elegy (3)
426. Roman Comedy (3)
427. Vergil (3)
428. Lucretius (3)
430. Medieval Latin (3-6)
431. Roman Satire (3)
432. Roman Rhetorical and Literary Theory (3)
436. The Teaching of Latin (3)
437. Latin Prose Composition (3-6)
460. Topics in Latin Literature (3-6)
461. (Ling. 461) History of the Latin Language (3)
489. Studies in Latin Literature (1-6)

500. Latin Literature (3-9) Readings in the major forms of Latin literature; content varies, course may be repeated.

501. Roman Religion and Philosophy (3) Development of religious concepts at Rome from primitive Italic origins to the advanced forms that culminated in Roman Stoicism. Prerequisites: two 400-level courses in Latin.

510. Latin Seminar (3-6)

518. Latin Research (1-6) Prosecution of an assigned problem under the guidance of a member of the department.

*CLASSICS (CLASS)

405. Greek and Roman Mythology (3)
406. Emergence and Development of Classical Poetic Genres (3)

*The readings are in English; knowledge of Greek and Latin is not required.

408. Greek Religion and Modern Man (3)
410. Classical Epic (3)
411. Classical Drama (3)
412. Classical Historians (3)
413. Readings in Classical Literature (3)

500. Introduction to Classical Scholarship (1-6) Lectures on the methods and materials of classical scholarship. To be scheduled by graduate students in their first term, and as necessary thereafter.

504. Topography of Ancient Rome (3) Lectures and readings on physical development of the ancient city of Rome from earliest habitation to time of later empire.

COMMUNITY SYSTEMS PLANNING AND DEVELOPMENT (CSP D)

JOE A. MILLER, *Chairman of Coordinating Committee*
104 Human Development Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Anderson, Arnold, Bortner, Freeman, Gottlieb, Gunter, Hunt, Mann, Newman, Raffel, Ritti, and Vallance.
Graduate Faculty: Associate Members Berry, Brown, Burns, Ellis, Gamm, Guttenplan, Hill, Katkin, Mayers, Meyer, Miller, Robinson, and Woolley.

This interdisciplinary program provides instruction in content and research methods relating to the coordinated planning, development, administration, and evaluation of a range of community services.

The Ph.D. program provides general coverage of the full range of problems and processes in community planning and offers opportunities emphasizing planning, development, and administration in health services, administration of justice services, community organizations, and social welfare services. The M.S. program emphasizes planning, development, and administration in the health services area.

The aim of the program is to build the knowledge base and skills necessary to assist communities to develop policies and programs for services needed by individuals and the community as a whole. Graduates of the program will be able to identify major community subsystems and recognize community problems and dysfunctions, expressing their relative seriousness in terms of economic and social costs. Graduates will have skill in working with community members to develop ways of coping with such problems and to facilitate the creation of interventions which will improve the quality of life. In addition, they will have the skills necessary to evaluate the effectiveness of these programs.

The communication requirement for the Ph.D. can be satisfied by demonstrating proficiency through examination in one foreign language or a set of computer languages.

Preference will be shown to applicants who have a broad background in the social sciences. Proficiency in quantitative skills such as mathematics and statistics is also desirable. In general, a 3.00 junior-senior average is expected of applicants, but consideration will be given to prior graduate education and professional work experience in community services, political processes, or such programs as Peace Corps and VISTA.

Special research and training facilities include the Pennsylvania Field Research Laboratory, the University Computation Center, and a simulation laboratory.

COMMUNITY SYSTEMS PLANNING AND DEVELOPMENT (CSP D)

501. HEALTH CARE ORGANIZATION (3) Examination of health systems, organization, financing, and evaluation; trends, problems, and issues.

521. VALUES AND GOALS IN THE ADMINISTRATION OF JUSTICE. (3) The justice system from perspective of clientele, service personnel, and the system. Meeting service requirements in community and institutional settings.

532. INTERFACE PROBLEMS OF COMMUNITY SERVICE SYSTEMS (3) Exploration of consequences of policy decisions and action in one or more social service systems on other community systems.

533. BEHAVIORAL ASSUMPTIONS AND STRATEGIES IN THE PROCESS OF PLANNED CHANGE (3) A general systems approach to the assumptions beneath various social problem strategies and consequences associated with each intervention-set.

534. FORECASTING METHODS AND SOCIAL POLICY PLANNING (3) Analysis of predictive methods for forecasting social change. Prerequisites: Econ. 405, Stat. 200.

COMPARATIVE LITERATURE (C LIT)

ROBERT LIMA, *In Charge of Graduate Programs in Comparative Literature*
N-346 Burrowes Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Begnal, Kopp, Lewis, Lima, Rosenberg, Shelley, and West.
Graduate Faculty: Associate Members Knight, Peavler, Walden, and Ward.

Programs of study in international literary and cultural relations are arranged in accordance with the individual student's interests through a meaningful selection of courses both in comparative literature and in the several national literatures, Topics appropriate to such programs include the currency, reception, and influence of writers and works in countries other than those of their origin; the origin, transmission, and evolution of international literary movements; the characteristics and relations of genres, themes, and motifs; folk literature and folklore; criticism; aesthetics; intermediaries; relationships between literature and other disciplines.

In addition to the general requirements for graduate degrees, there are the following special requisites. *Master of Arts* — Courses in comparative literature (9 credits) and two national literatures (9 and 6 credits), knowledge of the language of each of the two literatures to be demonstrated by examination, a written examination based on a reading list, and a thesis (6 credits). *Doctor of Philosophy* — The communication and foreign language requirement for the Ph.D. degree may be satisfied by courses in comparative literature and three national literatures, one of which may be English, knowledge of the languages of each of the three literatures to be demonstrated by examination, a written comprehensive examination, and a doctoral thesis. An M.A. degree in an appropriate area is a prerequisite for entry into the doctoral program. Students with a 2.65 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.65 grade-point average may be made for students with special backgrounds, abilities, and interests.

COMPARATIVE LITERATURE (C LIT)

401. WESTERN LITERATURE I (3) *Mrs. Eckhardt*
402. WESTERN LITERATURE II (3) *Mr. Knight*
403. WESTERN LITERATURE III (3) *Mr. Begnal*
408. HEROIC EPIC AND SONG (3) *Mr. Rosenberg*
420. TRADITION IN MODERN AFRICAN LITERATURE (3) *Mr. Hale*
421. MODERN AFRICAN LITERATURE: THE COLONIAL EXPERIENCE (3) *Mr. Hale*

443. (Ger. 443) Literary Relations of Germany with England and America (3-9) *Messers. Shelley and Kopp*
470. Old Masters of the Modern Novel (3) *Mr. Begnal*
480. Introduction to Folklore (3) *Mr. Rosenberg*
486. Tragedy (3) *Mr. Lima*
487. Comedy (3) *Mr. Knight*
488. (Engl. 488) Modern Continental Drama (3) *Messrs. Christopher and Crecco*
489. Special Subjects and Problems of Comparative Literature (3) *Staff*

500. Seminar in Comparative Literature (3-6) *Staff*

501. Comparative Method in Literary Studies (3) *Miss Ward*

502. Comparative Criticism I: Classical to Neoclassical (3) Issues in literary criticism from Plato and Aristotle to the mid-eighteenth century.

503. Comparative Criticism II: Romantic to Contemporary (3) Principles and theories of literary criticism from eighteenth- and nineteenth-century beginnings to twentieth-century expansion and application.

508. Norse and Gaelic Sagas (3) Medieval Irish and Scandinavian prose tales surveyed and compared with respect to background, development, themes, and characteristics. *Mr. Rosenberg*

570. Forces in Contemporary European Literature (3) The intellectual currents that have influenced European writers of the mid-twentieth century: Beckett, Böll, Robbe-Grillet, and others. *Mr. West*

588. Twentieth-Century Drama (3) The comparative analysis of major plays of the twentieth century. *Mr. Lima*

593. (Engl. 593) Anglo-American Folk Song (3) Survey of relevant literary and ethnological scholarship and field work, European and American, from the early sixteenth century to the present.

COMPUTER SCIENCE (CMPSC)

Paul Axt, *Acting Head of the Department*
107 Whitmore Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Barnes, Coffman, Day, deMaine, Gotterer, Hammer, Hsu, Jones, and Laird.
Graduate Faculty: Associate Members Bruno, Honkanen, Hosken, Hughes, and Johnson.

The department offers courses and is prepared to direct research in a variety of subfields of computer science, including information retrieval, theoretical foundations of computer science, computer languages and programming systems, numerical analysis and nonnumeric procedures. The Computation Center has modern digital equipment and systems available for research and instruction.

Admission to the M.S. program without deficiency requires the equivalent of Cmp.Sc. 401 and 410 and at least four of the six following: (1) Cmp.Sc. 404, (2) Cmp.Sc. 411, (3) Cmp.Sc. 420, (4) Cmp.Sc. 453 or 454, (5) Cmp.Sc. 468, (6) Math. 63 and 441. The remainder of these six must be completed for the M.S. and Ph.D.

The M.S. candidate must satisfactorily complete Cmp.Sc. 510, 511, and 540, in addition to the other requirements of the Graduate School. The nonthesis option is available for the M.S. degree.

The Ph.D. degree is primarily a research degree, and is conferred on the basis of original work and high academic achievement in computer science. In order to be accepted as a candidate the student must pass a six-hour written candidacy examination. The communication and

foreign language requirement for the Ph.D. degree may be satisfied by a proficiency in one foreign language (French, German, or Russian). These and additional requirements are detailed in the departmental brochure, *Computer Science at Penn State.*

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

COMPUTER SCIENCE (CMPSC)

401. Principles of Programming with Physical Science Applications (3)
402. Principles of Programming with Social and Biological Science Applications (3)
403. Principles of Programming with Business Applications (3)
404. Information Structures (3)
408. (Chem. 408) Computer Applications in Chemistry (3)
410. Introduction to Computer Systems (3)
411. Systems Organization and Programming (3)
420. The Structure of Programming Languages (3)
430. Combinatorics and Graph Theory (3)
450. Information Theory and Error-Correcting Codes (3)
453. (Math. 453) Numerical Computations (3)
454. (Math. 454) Matrix Computations (3)
468. Mathematical Machine Theory (3)
490. Special Topics in Computer Science (1-9)
491. Computer Projects (3)

500. Theory of Automata (3) The structure of finite automata and sequential machines including characterization theorems, minimization problems, state identification experiments and decomposition theory. Prerequisite: Cmp.Sc. 468.

501. Algebraic Theory of Automata (3) Prerequisite: Cmp.Sc. 500.

510. Structure of Artificial Languages (3) Structure of problem-oriented languages; syntactical description, algorithms for translation, list structures, string manipulation, formula manipulation, relation to linguisitcs. Prerequisites: 3 credits in logic or logical design at the 400 level, Cmp.Sc. 420.

511. Systems Programming (3) Interpretive systems; assemblers, loaders, compilers, library monitor systems; input-output scheduling; executive programs, job scheduling; multiaccess systems, multiprogramming, multiprocessing. Prerequisite: Cmp.Sc. 411.

530. Nonarithmetic Programming (3) Combinatorial problems, learning mechanisms, heuristic programs, and pattern recognition. Prerequisite: Cmp.Sc. 420 or 485.

535. Theory of Graphs and networks (3) Theory and applications of graphs including structure of graphs, network analysis and algorithms for computer solution of graph-theoretic problems. Prerequisite: Cmp.Sc. 430.

537. (B.A. 537) Management Information Systems Design (3) Cost, value, and technical considerations in analysis and design of information systems whose purposes are to aid decision making in organizations.

540. Information Processing Systems (3) Data structures and data processing; information retrieval systems. Prerequisite: Cmp.Sc. 411.

545. Information Retrieval (3) This course deals with input-output, design implementation, evaluation, global memories and comparison of information retrieval systems. Prerequisite: Cmp.Sc. 540.

552. (Math. 552) Numerical Analysis I (3) Interpolation; remainder theory; approximation of functions; error analysis; orthogonal polynominals; approximation of linear functionals; functional analysis applied to numerical analysis. Prerequisites: Math. 420, 453.

553. (Math. 553) NUMERICAL ANALYSIS II (3) Eigenvalue and eigenvector determination; numerical solution of integral equations and ordinary differential equations with error and stability analysis. Prerequisites: Math. 420, 454 or 480.

559. COMPUTABILITY AND RECURSIVE FUNCTIONS (3) Mathematical treatment of computability, recursive functions, Turing machines, unsolvable problems, recursive and recursively enumerable sets. Prerequisite: Cmp.Sc. 468.

560. COMBINATORIAL SYSTEMS (3) The relationships among various forms of combinatorial systems including Turing machines, Post normal systems, Thue systems and recursive functions. Prerequisite: Cmp.Sc. 559.

563. (Math. 563) APPROXIMATION THEORY (3) Approximation in normed spaces; existence, uniqueness, characterization, computation of best approximations; error bounds, degree of approximation; approximation of linear functionals. Prerequisites: Math. 453, 501.

564. (Math. 564) NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS (3) Numerical solution of initial and boundary-value problems; eigenvalues and eigenfunctions; errors, stability, and convergence. Prerequisite: Math. 552.

566. (E.E. 566) ALGEBRAIC CODING THEORY (3) Polynomial rings, galois fields, linear codes, cyclic codes, BCH codes, finite projective geometry cyclic codes, convolution codes, graph theoretic codes. Prerequisite: Cmp.Sc. 450 or E.E. 561.

568-569. THEORY OF FORMAL LANGUAGES AND AUTOMATA (3 each) Generation and recognition of formal language, grammar, Chomsky's hierarchy of languages, closure properties, characterization by automata, algebraic properties, complexity classification. Prerequisite: Cmp.Sc. 468.

579. (Math. 579) SPECIAL TOPICS IN NUMERICAL ANALYSIS (2-12)

591. SPECIAL TOPICS IN COMPUTER SCIENCE (2-6)

COUNSELOR EDUCATION (CN ED)

EDWIN L. HERR, *Head of the Department*
323 Social Sciences Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Britton, Herr, Hudson, Hylbert, Kelz, Swisher, and Wellington.
Graduate Faculty: Associate Members Horan, Keat, and Upcraft.

Professional preparation is offered at the master's level for school counselors (elementary and secondary), college counselors or persons entering college student personnel services, and rehabilitation counselors. Doctoral programs prepare candidates for positions of responsibility and leadership in these same areas as well as in the education of counselors. Doctoral candidates must have a minimum of one year's work experience in their field.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign languages.

All candidates for graduate degrees in counselor education must present for admission at least 27 undergraduate credits of 3.00 or better distributed among at least three of the following areas: economics, education, psychology, sociology, and physiology or anatomy.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. Doctoral candidates should present a 3.33 average in all graduate study completed.

All candidates are expected to exhibit, in addition to academic competence, effectiveness in interpersonal relations and in both written and oral communication. They must also evidence support of professional counseling activities and organizations.

A candidate for either a Ph.D. or a D.Ed. must earn at least 30 credits in six or fewer consecutive terms in residence after completing the master's degree, preferably at the thesis planning and writing stage.

COUNSELOR EDUCATION (CN ED)

403. Foundations of Guidance and Counseling Processes (3)
404. Group Procedures in Guidance and Counseling (3)
408. Introduction to Vocational Rehabilitation (3)
409. Medical Information for Counselors (3)
410. Rehabilitation of the Mentally Ill (3)
412. Rehabilitation Facilities and Services of Pennsylvania (3)
413. Rehabilitation Case Recording and Management (3)
425. The Use of Tests in Counseling (3)

501. Counseling: Theory and Method (3) Theory and methods of counseling individuals whose problems of choice, decision, and adjustment fall within the normal range. Prerequisite: Cn.Ed. 403 or 408 or 551.

503. Guidance Services in Elementary Education (3) Guidance services to elementary school students; guidance opportunities for elementary teachers and principals. Prerequisite: Cn.Ed. 403.

504. Guidance Services in Secondary Education (3) Nature and scope of guidance in secondary schools — services, models, and strategies; the counselor as an agent of change. Prerequisite: Cn.Ed. 403.

505. Foundations of Counseling Information (3) Accelerating change in economic, psychological, social, educational influences upon counselees. Utilization of information systems in effecting counselee change. Prerequisite: Cn.Ed. 403 or 408 or 504 or 551.

506. Individual Analysis and Counseling Procedures (3) Collection and use of data basic to the counselor's understanding of individuals; the counseling interview and techniques other than testing. Prerequisites: Ed.Psy. 451 and Cn. Ed. 408 or 503 or 504.

507. Counseling Practicum (1-6) Practice in the application of guidance principles and methods to cases counseled under supervision; case conferences; seminar in guidance techniques. Prerequisite: Cn.Ed. 506.

508. Organization and Administration of Guidance Programs (3) Principles, organization, personnel, functions, integration with school programs, evaluation. Prerequisite: Cn.Ed. 506.

509. Contributions of Professional Personnel to Vocational Rehabilitation (3) Contributions of medical, social, psychological, and other specialists through the team approach; professional ethics, medical problems. Prerequisites: Cn.Ed. 403, 408.

511. Supervised Practicum in Rehabilitation Counseling (1-6) Application of principles and techniques of rehabilitation counseling to cases involving handicapped individuals. Prerequisites: Cn.Ed. 403, 408.

512. Professional Experience in Rehabilitation Counseling (1-6) Supervised internship with responsibility for a regular case load. Prerequisites: Cn.Ed. 403, 408.

513. Supervision of Counselors (3-9) Practical experience in supervising and evaluating work of counselors. Prerequisite: Cn.Ed. 507.

514. Evaluation of Projects in School Guidance (2-6) The analysis of factors in and the completion of program development projects in cooperation with state or local guidance programs. Prerequisite: 15 credits in counselor education.

515. Seminar in Counseling, Guidance, and Rehabilitation (1-9) Conferences and discussions designed to meet the need for special study of particular topics in counseling, guidance, and rehabilitation. Prerequisite: 9 credits in counselor education.

516. Evaluation of Projects in School Guidance (2-6) Implementation and evaluation of program development projects in cooperation with state or local guidance programs. Prerequisite: 15 credits in counselor education.

551. Student Personnel Services (2-3) Student personnel services in higher education; organization of student advisory programs; use of personnel data; cocurricular activities; student welfare.

553. Student Personnel Services Programming (2-3) Formulation of policies as guides to the student personnel service programs; integration of program elements; research; current problems and trends. Prerequisites: Cn.Ed. 551, Hi.Ed. 545.

589. Problems, Projects, and Area Studies in Counselor Education (1-6) Independent work in the study of topics in counselor education, or development of new curriculums, materials, or procedures for teaching.

591. Seminar in Counseling: History and Trends (1) Discussion of the history of guidance and counseling, emphasizing how the past has shaped the present and protends the future. Prerequisite: 9 credits in counselor education.

592. Seminar in Counseling: Legal and Ethical Concerns (1-2) Study and discussion of legal, ethical, and professional concerns of counselors; privileged communication, data banks, and privacy invasion. Prerequisite: 9 credits in counselor education.

593. Seminar in Counseling: Philosophy (1) Study and discussion of such philosophical foundations of counseling as phenomenology, idealism, realism, existentialism, daseinanalytic, theological, and other contemporary thoughts. Prerequisite: 9 credits in counselor education.

DAIRY SCIENCE (D SC)

Donald W. Josephson, *Head of the Department*
111 Borland Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Almquist, Amann, Dimick, Flipse, Josephson, Keeney, Kesler, Kroger, McCarthy, Patton, Tanabe, and Watrous.
Graduate Faculty: Associate Members Buckalew, Glass, Hargrove, Shellenberger, and Thoele.

Students may specialize in dairy products manufacture, chemistry of milk and dairy products, lipid metabolism, dairy cattle nutrition, dairy cattle genetics, dairy cattle management, and physiology of reproduction. The minor program is generally taken in biochemistry, microbiology, physiology, or agricultural economics. The communication and foreign language requirement for the Ph.D. degree may be satisifed by intermediate knowledge of one foreign language.

Prerequisite to graduate work is the completion of an undergraduate major in animal industry, animal science, dairy science, food technology, or a related area. The undergraduate program must include college algebra and general physics. Students may be admitted with limited deficiency but are required to make up undergraduate deficiency work without degree credit.

Students with a 2.70 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.70 grade-point average may be made for students with special backgrounds, abilities, and interests.

DAIRY SCIENCE (D SC)

405. Dairy Cattle Management (3) *Mr. Buckalew*
418. Dairy Survey (1) *Mr. Shellenberger*
Milk Secretion (1) *Mr. Kesler*
428. Dairy Production Problems (1-6) *Mr. Kesler and Staff*
431. Physiology of Reproduction in Farm Animals (3) *Messrs. Almquist and Amann*

507. Dairy Cattle Management (1-6) *Mr. Buckalew and Staff*

508. Dairy Seminar (1-6) Preparation and presentation of a paper on an assigned subject.

511. Dairy Cattle Nutrition (1-6) Nutritional requirements of dairy cattle. Prerequisite: A.Ntr. 401. *Mr. Kesler*

512. Advanced Studies in Milk Secretion (1-6) Physiology of milk secretion. Prerequisite: D.Sc. 427. *Mr. Kesler*

513. Dairy Cattle Breeding (1-6) Interpretation and application of current knowledge in genetics to dairy cattle breeding and selection. Prerequisites: An.Sc. 322, Biol. 422, 3 credits in statistics. *Mr. Hargrove*

515. Advanced Physiology of Reproduction in Farm Animals (1-6) *Mr. Almquist*

516. Artificial Breeding of Farm Animals (1-6) Prerequisite: D.Sc. 431. *Mr. Almquist*

517. Dairy Science Literature (1-6) Review and reporting of dairy literature. *Staff*

521. Dairy Radiophysiology (3) Metabolism and physiology of radioactive compounds; their use as tracers in animal physiology and the effects of radiation on metabolic processes. Prerequisite: Chem. 405. *Mr. McCarthy*

Note: *See Animal Science under "Other Elective Graduate Courses." Also see Food Science.*

DEVELOPMENTAL AND REMEDIAL READING (D R R)

Arthur W. Heilman, *In Charge of Graduate Program in Developmental and Remedial Reading*
230 Cedar Building

Degree Conferred: M.Ed.

Graduate Faculty: Senior Members Bliesmer and Heilman.

The purpose of the master's program is to prepare classroom teachers in elementary and secondary schools for more effective teaching of reading and to provide preparation for supervisory and administrative positions relative to reading in school systems.

Candidates for a master's degree must meet the requirements for admission to graduate study and, in addition, (1) must hold, or be eligible to hold, a valid teaching certificate (persons not meeting this criterion may work on overcoming deficiencies; graduate credit, but not degree credit, may be received for graduate courses taken to overcome such deficiencies) and (2) must have had at least one year of teaching experience or the equivalent.

The master's program has been planned so that those completing the program will also meet the state requirements for "reading specialist" certification.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

DEVELOPMENTAL AND REMEDIAL READING (D R R)

441. Fundamentals of Reading Instruction (3)
442. Reading Problems in the Secondary Schools (2)
444. Practicum in Elementary Remedial Reading (3)
445. Practicum in Secondary Remedial Reading (3)
446. Remedial Reading in the Classroom (3)
447. Teaching Reading and Literature to Adolescents (3)

540. TEACHING READING: LINGUISTICS PERSPECTIVE (3) Examination of reading as language and thought processes; contributions of linguistics, orthography, semantics, and syntax to instructional strategies. Prerequisite: undergraduate reading course and teaching experience.

545. DIAGNOSTIC TESTING IN READING (3) Practicum in diagnosing reading difficulties, elementary and secondary levels; achievement, diagnostic, and capacity tests; informal inventories; genesis of reading problems. Prerequisites: El.Ed. 443 and D.R.R. 444 or 445.

546. READING INSTRUCTION (3-6) Research, procedures and materials in reading readiness, word perception, basic reading skills, vocabulary development, reading in content subjects. Prerequisite: 6 hours of graduate credit in D.R.R.

557. PRACTICUM: REMEDIAL PROCEDURES AND DIAGNOSIS (3-6) Advanced practicum; diagnostic testing and remedial instruction of more severe types of reading disability; newer and special materials and procedures. Prerequisite: D.R.R. 545.

559. STUDIES OF RESEARCH IN READING (3) Intensive study of research in such areas as vocabulary; readiness; instructional approaches; rate; measuring capacity; readability; difficulty causes; sex differences. Prerequisite: 6 hours of graduate credit in D.R.R.

580. STUDIES IN DEVELOPMENTAL AND REMEDIAL READING (1-6) Independent and intensive study of topics in reading which relate to research, instructional trends, new materials and total curricular programs. Prerequisite: 9 hours of graduate credit in D.R.R.

EARTH SCIENCES (EARTH)

E. WILLARD MILLER, *Chairman of the Committee on Earth Sciences*
101 Mineral Sciences Building

Degrees Conferred: D.Ed., M.Ed.

Graduate Faculty: Senior Members Blackadar, Cuffey, Dutton, Guber, Lewis, Miller, Panofsky, Thornton, Weber, Wernstedt, Williams, and Wright.
Graduate Faculty: Associate Members Hovermale, Lavin, Lavoie, J. Pena, and R. Pena.

The M.Ed. program is designed to meet the needs of science teachers in secondary schools. The fields of study are astronomy, geography, geology, geophysics, meteorology, and mineralogy. The student selects one of the earth sciences as an area of concentration, takes at least 12 credits in it, and is required to write a term paper in that area. An additional 12 credits must be taken in at least two other fields of earth sciences, or in two earth science fields plus two courses selected from the biological sciences, chemistry, mathematics, or physics. Furthermore, 6 credits in educational foundations are required as a minor.

The D.Ed. program is designed for secondary school and college science teachers. The major course requirements are designed by the candidate's committee with one area of concentration in the earth sciences plus courses from at least two other earth science areas. The program is designed to investigate problems which arise from the complex interaction of man's technological and social activities with the natural environment. A minimum of 15 credits each is required in professional education and in thesis research.

Students with a 2.50 junior-senior average, 18 credits in education and related psychology, and with other appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

The following courses offered by the various departments are appropriate for students majoring in earth sciences: Astro. 430; Geog. 433, 434; Geol. 400, 401, 402; Gphys. 400; Meteo. 400, 401, 402, 403, 404; Min. 402.

EARTH SCIENCES (EARTH)

400. Earth Sciences Seminar (3)

500. Earth Sciences Research (1-6) Relationships between the earth sciences revealed by theory, analytical methods, or a selected problem.

ECOLOGY (ECLGY)

Edwin L. Cooper, *In Charge of Graduate Programs in Ecology*
315 Life Sciences I Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members P. Baker, Bellis, Butler, Cooper, Cuffey, Dunson, Graves, Guber, Hutnik, Kim, McDonnell, Patil, Rothenbacher, Schein, Wagner, and F. Williams.
Graduate Faculty: Associate Members Adams, DeWalle, and Hower.

This intercollege program emphasizes the properties of ecosystems by focusing attention on interactions of single organisms, populations, and communities with their environment. It is designed to give students a basic understanding of ecological theory and is, therefore, complementary to other environmental programs which emphasize man's role in ecosystems.

The instructional program includes three graduate core courses in ecology, augmented by an additional integrated group of seminars and courses selected for each student by his committee, and a research project directed by the thesis adviser. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language. The nonthesis option is available for the M.S. degree.

The program is administered by a committee drawn from faculty members in several departments and colleges of the University. This committee and its chairman are appointed by the Dean of the Graduate School. The instructional staff is composed of participating faculty in those departments offering graduate courses in fields closely allied to ecology.

The committee appointed by the Graduate School for each candidate in ecology is selected from members of the program committee and faculty from the student's area of specialization. The committee has the responsibility for determining the course program and research acceptable in satisfying degree requirements.

Students meeting the admission requirements of the Graduate School will be considered up to the number of spaces available in selecting candidates in this program. Candidates should have a strong science background including chemistry, physics, and mathematics. Preparation in biological sciences is also desirable. Students with a unique background in another discipline which has potential value to original ecological work will be seriously considered.

Detailed descriptions of courses now available for students majoring in ecology may be found under the offerings of several departments: Agro. 422; Anthy. 502-503; Biol. 410, 419, 450, 451, 480, 481, 516, 519, 546; C.E. 472, 579, 580; Cmp.Sc. 402; Ent. 416, 517, 535; E.R.M. 410, 413; For. 508, 517; Geol. 430, 435, 503; Meteo. 505; Micrb. 400, 413; Phil. 512; P.Path. 424; Stat. 524; V.Sc. 401; Wildl. 446.

ECONOMICS (ECON)

GRANT N. FARR, *Head of the Department*
613 Kern Graduate Building

Degrees Conferred: Ph.D., M.A., M.Ed.

Graduate Faculty: Senior Members Budd, Coppock, Farr, Feller, Herendeen, Hu, Kaufman, Klein, Mason, Myers, Newman, Riew, Robinson, Rozen, Sauerlender, Smith, and Stout.
Graduate Faculty: Associate Members Booms, Cohn, Fox, Friedrich, Nelson, and Rodgers.

Opportunities are available for concentration in the following fields: economic analysis, economic doctrines, economic development of developed areas, economic development of underdeveloped areas, economic fluctuations, income distribution, industrial organization, international economics, comparative economic systems, labor economics, money and banking, public finance, quantitative economics, statistics, and regional economics.

Students may also qualify for admission to the program in population issues, consisting of interdisciplinary course work with special emphasis on the economic, social, and geographic issues arising from the dynamics of population change.

The communication and foreign language requirement for the Ph.D degree may be satisfied by any of the following alternatives: (1) a reading knowledge of two foreign languages, (2) a reading knowledge of one foreign language and 6 credits of other course work from designated areas which increase research skills, (3) the equivalent of 12 credits of departmentally approved course work which increases research skills, or (4) a comprehensive knowledge of one foreign language. The nonthesis option is available for the M.A. degree.

To enter graduate work in economics a student should have completed 6 credits in economic principles, 9 in the social sciences, and either 3 in statistics or 6 in mathematics. All applicants must take the Graduate Record Examination in advanced economics and general aptitude.

Students with a 2.50 junior-senior average, a 3.00 average in courses in economics, and appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

ECONOMICS (ECON)

400. History of Economic Thought I (3)
401. History of Economic Thought II (3)
404. Current Economic Issues (3)
405. Advanced Economic Analysis (3)
412. Economics of Collective Bargaining (3)
413. (L.S. 413) Comparative Labor Movements (3)
414. (L.S. 414) Theories of the Labor Movement (3)
415. Social Insurance (3)
418. Economics of Wages and Employment (3)
419. Case Studies in Labor-Management Relations (3)
423. State and Local Taxation (3)
424. Urban Economics (3)
427. (Ed.Adm. 427) Economics of Education (3)
429. Advanced Public Finance (3)
433. International Monetary Economics (3)
435. Labor Relations in the Public Sector (3)
442. Monopoly, Competition, and their Regulation.
450. The Business Cycle (3)
451. Monetary Theory and Policy (3)
461. Economic Growth: Underdeveloped Areas (3)
462. Economic Growth: Theories of United States Development (3)
463. Economic Demography (3)

480. Mathematical Economics (3)
489. Selected Topics in Economics (3)
490. Introduction to Econometrics (3)
491. Analysis of Linear Economic Models (3)
499. Foreign Study in Economics (2-6)

500. Economic Seminar (3-6)

502. Microeconomic Analysis (3) Economic behavior under pure and imperfect competition; price and output determination in product markets; prices and employment in factor markets.

503. Macroeconomic Analysis (3) National income accounts; determination of income, employment, interest rates, and the price level; stabilization policy.

506. Problems in Economics (1-12) Planned projects involving library, laboratory, or field work.

507. International Trade (3) A survey of international trade theory including modern developments of pure theory, and of international trade policy.

508. Current Monetary Theory and Policy (3) Post-Keynesian reformulation of quantity and Keynesian theories of money; liquidity and general equilibrium approaches; current issues in theory and policy.

510. Econometrics (3-6) Statistical estimation in mathematically formulated economic relationships.

513. Development of Economic Doctrines (3-6)

515. Economics of the Labor Market (3) Theory and problems of labor-management relations; selected problems of the labor market with reference to current research and developments.

516. Economics of Human Resources (3) Analysis of changes in human resource supply and demand; factors affecting these changes; current human resource policies.

517. International Finance (3) Problems of international liquidity; balance of payments adjustment; international financial institutions and selected policy problems.

518. Development of Monetary Theory (3) Classical and neoclassical quantity theories of money and contemporary criticism; Keynesian monetary theory and its critics.

521. Advanced Microeconomic Theory (3-6) Theory of consumer behavior; theory of the firm; price determination in product and factor markets; introduction to welfare economics.

522. Advanced Macroeconomic Theory (3-6) Measurement of income; theories of consumption, investment, and money holdings; static determination of income and employment; introduction to dynamic analysis.

524. Income Distribution (3) Measurement of inequality; ethical issues in income redistribution; measurement and determination of distributive shares; problem of poverty.

525. Economics of Technological Change (3) Theoretical and empirical analysis of invention and innovation and their effects on productivity, employment, and market structure.

528. Advanced Economic Theory: Selected Topics (3) Treatment of topics in economic theory to meet needs of advanced students seeking intensive work in selected areas.

529. Public Finance (3-6) Contemporary problems in public finance; instruments of fiscal policy in the achievement of full employment, price stability, and economic development.

530. Regional Microeconomics (3) Theoretical and empirical analysis of industrial location as determined by costs, markets, and agglomeration effects.

531. Regional Macroeconomics (3) Aggregate regional trade flows; sources of regional economic data; techniques for measuring regional economic activity; long-run regional growth.

543. Industrial Organization and Public Policy (3) The structure of American industry; performance and behavior; public policies toward business.

550. Economic Fluctuations (3) Analysis of the various theories of economic fluctuations; their methodological premises.

551. Stabilization Policy (3) Description and analysis of the alternatives and issues in stabilization policy.

560. Seminar in Economic Growth: Underdeveloped Areas (3-6) Resources and institutions; quantitative measures; theories of economic growth in developing areas; developmental policies.

561. Seminar in Economic Growth: Developed Areas (3-6) Growth models; strategic factors in growth; quantification problems; public policy.

571. Comparative Economic Systems (3-6) Comparative analysis of alternative resource allocation principles; growth and performance of different economic systems; problems of decision making and control.

572. Soviet and Other Centrally Planned Economics (3-6) Principles, structure, and performance of centrally planned economies with special emphasis on the Soviet Union.

580. Mathematical Economics (3-9) Mathematical development of static and dynamic economic models: partial and general equilibrium analysis; growth dynamics; mathematical programming. Prerequisite: Econ. 480.

595. Seminar in Econometric Theory (3-6) Advanced study in the theories and problems relevant to the application of statistical methods to economics. Prerequisites: 6 credits of Econ. 510 and Math. 409.

EDUCATION OF EXCEPTIONAL CHILDREN (E E C)

JOSEPH L. FRENCH, *In charge of Graduate Programs in Education of Exceptional Children*
102 Cedar Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Anderson, Bliesmer, G. Cartwright, French, Frick, Heilman, McDonald, Siegenthaler, and Smith.
Graduate Faculty: Associate Members Berlin, C. Cartwright, Salvia, Strollo, Vitello, Ward, and Ysseldyke.

Exceptional children are those who deviate so far from average in physical, intellectual, emotional or social characteristics that they cannot profit adequately from the usual public school program. It is the purpose of this program to prepare teachers, researchers, administrators, and college and university teachers in the areas encompassing the education of the mentally retarded, gifted, emotionally disturbed, neurologically impaired, or learning disabled. A multidisciplinary approach is emphasized. The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign languages.

Prerequisites for a master's program include: 20 credits basic to the education of exceptional children (courses comparable to E.E.C. 400, 401, 454, 410 or 430 or 470; D.R.R. 441; Mth.Ed. 420; and a 400-level course in foundations of education).

Highest admission priorities are given to applicants who possess certification in special education or elementary education. Applicants for master's and doctoral programs must present evidence of superior academic achievement and aptitude, complete a personal statement, and provide professional references. Applicants for doctoral study must have had at least two years relevant experience with handicapped children.

EDUCATION OF EXCEPTIONAL CHILDREN (E E C)

400. Introduction to Exceptional Children (3)
401. Educational Adjustments for Exceptional Children (3)
403. Clinical Teaching with Exceptional Children (3)
405. Practicum in the Education of Exceptional Children (1-12)
410. The Mentally Retarded (3)

420. The Mentally Gifted (3)
430. Learning Disabilities (3)
440. (S.P.A. 440) Survey of Speech and Hearing Disorders (3)
454. Diagnosis of Educational Disabilities (3)
460. Education of Visually Handicapped Children (1)
470. The Emotionally Disturbed (3)
472. Educational Problems of Urban Alienated Youth (3)
480. The Neurologically Impaired (3)
496. Workshop in Special Education (1-9)

500. Seminar in Special Education (1-9) Continuing series of professional seminars designed to provide a forum for discussion of current and classical research concerning exceptional children. Prerequisites: Ed.Psy. 400 and 6 credits in education of exceptional children.

501. Administration and Supervision of Educational Porgrams for Exceptional Children (2-3) Problems connected with the instituting and organizing of classes for atypical children; the legal phases, finances, teaching personnel, pupil personnel, housing, equipment, courses of study, curriculum, etc. Prerequisites: E.E.C. 401 and Ed.Ser. 480 or teaching or administrative or supervisory experience.

502. Internship in Special Education (2-10) Internship to take place in schools or educational situations where student is not regularly employed, under supervision of graduate faculty. Prerequisite: E.E.C. 405 or teaching experience.

505. Practicum (1-6) Supervised clinical experience on campus in University-managed diagnostic and remedial settings.

506. Field Experiences in Off-Campus Laboratories (1-10) Supervised off-campus field experiences in selected laboratory settings with exceptional children. Prerequisite: E.E.C. 505.

509. Problems, Projects, and Area Studies in Special Education (1-9) May not be used for thesis credit. Prerequisite: 12 graduate credits in special education.

510. Problems in the Education of the Mentally Retarded (2-4) Study of existing curriculums, instructional practices, educational programs; experimentation in curriculum building and materials construction. Prerequisites: teaching experience and E.E.C. 410.

520. Problems in the Education of the Mentally Gifted (2-4) Analysis of educational needs of mentally gifted; curriculum construction and curricular materials. Prerequisites: teaching experience and E.E.C. 420.

530. Problems in the Education of the Learning Disabled (2-4) Review of the research and theoretical implications in the educational and behavioral management of learning disabled children. Prerequisite: E.E.C. 430.

545. (S.P.A. 545) Cerebral Palsy (3) Etiology and symptomatology of cerebral palsies; diagnosis and treatment of communication problems; the multiprofessional habilitative program. Prerequisite: S.P.A. 444.

547. (S.P.A. 547) Language Disorders in Children (2) Nature, etiology, diagnosis, and management of language disorders in children. Prerequisite: 9 credits in speech pathology and audiology or related fields such as psychology, linguistics, or human development.

554. Psychological and Educational Evaluation of Exceptional Children (3) Administration and interpretation of individual tests other than the Stanford-Binet, WISC, WAIS. Prerequisite: Psy. 559.

570. Problems in the Education of the Emotionally Disturbed (2-4) Prerequisite: E.E.C. 470.

572. Seminar in the Education of Alienated Groups (2) A study of the alienated and educational issues of coping with problems of social, cultural, and economic deprivation. Prerequisite: E.E.C. 472.

573. Problems of Research with Alienated Groups (2) A seminar to review and design research studies for the education and training of alienated groups. Prerequisites: E.E.C. 472, 572.

580. PROBLEMS IN THE EDUCATION OF THE NEUROLOGICALLY IMPAIRED (2-4) Prerequisite: E.E.C. 480.

EDUCATIONAL ADMINISTRATION (EDADM)

PATRICK D. LYNCH, *In Charge of Graduate Programs in Educational Administration*
318 Rackley Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members DeLacy, Lutz, Lynch, and Willower.
Graduate Faculty: Associate Member Caldwell.

Professional preparation programs are offered at the master's and doctor's degree levels for elementary and secondary school personnel whose objectives are to become prepared in education policy-making positions such as principals, supervisors, superintendents, intermediate unit officials, state and federal education agency personnel, professors of educational administration, and/or researchers in educational administration.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign and native American languages.

Requirements for admission to a graduate program in educational administration ordinarily include 18 approved undergraduate credits in education and psychology. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. All applicants for any graduate program, including certification, must submit either a Miller Analogies Test or Graduate Record Examination (Quantitative and Verbal) score. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

All candidates who seek M.Ed. and M.S. degrees in educational administration shall complete programs embracing a minimum of 30 graduate credit hours. In only rare instances, however, to fulfill unusual objectives will candidates be permitted to work toward the M.S. degree. In Pennsylvania a certification program consisting of at least 45 hours is required before one can become a public school administrator.

Candidates for the D.Ed. and Ph.D. degrees are required to complete a minimum of three consecutive terms in residence.

From the time of initiation of a 600-level thesis research program, all doctoral candidates shall continuously register for a minimum of 2 credits per term until the termination of the graduate program. Failure to register for doctoral thesis credits in any term shall be considered automatic withdrawal. Specific requirements with respect to the Ph.D. and D.Ed. degrees may be learned from a departmental bulletin that is available upon request. Although candidates are required to specialize in a field of educational administration, they are encouraged to acquire a general education in the social sciences and the humanistic foundations.

EDUCATIONAL ADMINISTRATION (EDADM)

427. (Econ. 427) ECONOMICS OF EDUCATION (3)
460. INTRODUCTION TO ADULT EDUCATION (3)
480. EDUCATIONAL ADMINISTRATION (2-3)
481. COLLECTIVE NEGOTIATIONS IN PUBLIC EDUCATION (3)

525. FEDERAL EDUCATION POLICIES (3) Analysis of federal role in development of educational policy and its relationship to state and local policy.

528. (Pl.Sc. 528) POLITICS AND EDUCATION (3) Social forces which shape the educational system and determine national, state, and local educational policies.

533. THE POLITICS OF LOCAL SCHOOL DISTRICTS (3) The methodology of studying political decision making and the theory and practice of politics in local school districts. Prerequisite: 6 credits of sociology, anthropology, or political science.

560. SYSTEM THEORY IN EDUCATION (3) Concepts of general system theory, the systems approach, and related methodologies and tools; applications in education; critique of instructional systems. Prerequisites: Ed.Psy. 400, 475.

565. PERSONNEL AND GRIEVANCE ADMINISTRATION (2-3) Practice and theory of personnel supervision at the central office and building level, including contract administration and grievance handling. Prerequisites: 18 credits in education and three years' teaching experience.

567. ORGANIZATIONAL SUPERVISION (3) The organizational context of the school, its relationship to supervision, and the improvement of instruction. Prerequisites: Ed.Adm. 480 and teaching experience.

568. THE PRINCIPALSHIP (2-3) For elementary and secondary principals. The administrative and management tasks of building administration. The social system, change, and community relationships.

569. PRINCIPALSHIP SEMINAR (2-3) The study and application of interdisciplinary based products and processes in the various organizational units within the educational system.

571. THE EDUCATIONAL PLANT (2-3) School plant needs in terms of school population and curriculums; the building survey, developing a plant program, the building site, plant utilization, operation and maintenance, heating and ventiliation, equipment, school building costs and finance. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.

572. ANALYSIS OF SCHOOL-COMMUNITY RELATIONS (2-3) School-community relationships; social structure, social change, and the schools; case studies of community-school problems. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.

573. PUBLIC SCHOOL FINANCE (2-3) Financing of public education in relation to organization and control; the conceptual basis for local financial administration; taxation, state and federal aid, school revenue, and money management. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.

574. THEORY AND PRACTICE OF EDUCATIONAL NEGOTIATIONS (2-3) Theoretical framework, bargaining strategies, legislation, administrative roles, agreements, etc. Prerequisites: Ed.Adm. 480 or teaching or administrative or supervisory experience, and previous work in school administration.

575. ADMINISTRATION OF ADULT EDUCATION IN THE PUBLIC SCHOOLS (3) The organization of a program of adult education; its legal status, finances, selection of teachers, learning personnel, housing, and other administrative problems connected with adult education. Prerequisite: Ed. Adm. 480 or teaching or administrative or supervisory experience.

576. LEGAL ASPECTS OF SCHOOL ADMINISTRATION (3) Legal bases for the organization and administration of school districts and schools; the powers, rights, privileges, and responsibilities of school corporations, school boards, administrators, and personnel; the law and fiscal policies, the course of study, textbooks; contracts; taxes, torts; records; agents; and the judicial decisions involved. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.

578. DYNAMIC FACTORS IN SCHOOL ADMINISTRATION (2-3) Intraorganizational relationships; administration and the school as a social system; formal and informal organization. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.

579. PUBLIC SCHOOL BUSINESS ADMINISTRATION (2-3) Business management applied to school management problems; budgeting, accounting, purchasing, insurance, school equipment, cafeteria management; transportation, salaries, personnel management, and auxiliary and coordinate agencies. Prerequisites: Ed.Adm. 480 or teaching or administrative or supervisory experience; Ed.Adm. 573.

580. THE USE OF THEORY IN EDUCATIONAL ADMINISTRATION (1-6) Administrative theories applied to educational organizations. Prerequisites: Ed.Adm. 480, 6 credits in educational administration.

581. Field Research in Educational Administration (2-3) Methods of appraisal of an educational program; planning for expansion, consolidation, or reduction of educational offerings. Prerequisites: Ed.Adm. 480, 6 credits in educational administration.

582. Internship in Administration and Supervision (1-12) Internship to take place in schools or educational situations where student is not regularly employed, under supervision of graduate faculty.

588. Workshop in Current Educational Problems (1-6) For administrators, supervisors, experienced elementary and secondary teachers, guidance workers; administrative, supervisory, and instructional problems involved in an emerging educational program. Prerequisite: 12 credits of graduate work in education.

589. Problems, Projects, and Area Studies in Educational Administration (1-6) Independent work in the study of topics in educational administration, or development of new curriculums, materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of the department head.

591. Seminar in Public School Research (1-4) Doctoral candidates present outlines of their theses to the Graduate Faculty of the department and advanced graduate students.

EDUCATIONAL PSYCHOLOGY (EDPSY)

William Rabinowitz, *Head of the Department*
201 Social Sciences Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members DiVesta, French, Games, Hayman, Mitzel, Rabinowitz, Seibel, Thevaos, and Withall.
Graduate Faculty: Associate Members Hall, Sanders, Schwartz, Snyder, and Weener.

Graduate work is offered in the general field of educational psychology. Students may specialize and do research in school learning, educational and psychological measurement, statistics and research design as applied to education, and the psychology of instructional systems. Other areas of study related to educational psychology, such as counseling and guidance, clinical psychology, and special education, are offered in other departments of the University.

Doctoral degree requirements include a major emphasis in one of the above areas of educational psychology with minor emphasis in one other related area. Typically, the doctoral program of study would include a minimum of one course in each of the following areas: research methods, educational and/or philosophical foundations, computer science, human learning, measurement, social or industrial psychology, experimental psychology, and developmental psychology. In lieu of the foreign language requirement for the Ph.D. degree, it is expected that a student will present to his committee a plan for meeting his objectives, stating his goals and the academic and nonacademic work he expects to undertake in achieving these goals. Within the context of the above, the student will be expected to incorporate relevant experiences which are now part of the language and communication requirements, whether in course work, research, or teaching to increase his effectiveness as an educational psychologist.

Special facilities include a research design laboratory, a laboratory for computer-assisted instruction, rooms for conducting research projects, facilities for film production and editing, and a closed-circuit television studio used for both research and instruction. Other facilities available to students majoring in educational psychology are the Nursery School, the Psychology Clinic, the Reading Center, the Special Education Center for Children, the Division of Instructional Services, and the Speech and Hearing Clinic. The Computation Center, with several computer systems, is available for use in graduate student research.

Students with a 3.00 junior-senior average and a broad undergraduate background including some college mathematics will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abili-

ties, and interests. Applicants are required to submit scores on the Graduate Record Examination. Applicants with a master's degree will be required to show more than minimum success in graduate study, including at least one-half of their graduate credits of "A" quality.

EDUCATIONAL PSYCHOLOGY (EDPSY)

400. Introduction to Statistics in Educational Research (3)
406. Applied Statistical Inference for the Behavioral Sciences (3)
421. Learning Processes in Relation to Educational Practices (3)
450. (Psy. 450) Principles of Measurement (3)
451. Appraisal and Interpretation of Standardized Group Tests (2)
475. Introduction to Educational Research (2)
476. Experimentation in Educational Psychology (3)

501. Current Topics in Educational Psychology (2-6) Study of the current literature in educational psychology with emphasis on historical and theoretical aspects of important areas of investigation. Prerequisites: Ed.Psy. 406, 450, and 421.

506. Advanced Techniques for Analyzing Educational Experiments (3) Analytical and experimental control considerations for designs involving nested and/or crossed subjects. Analysis of variance and multiple comparisons via computers. Prerequisites: Ed.Psy. 406 and 407, or Psy. 415.

507. Multivariate Procedures in Educational Research (3) Introduction to matrix algebra, computer programming, multiple regression analysis, multiple and canonical correlation, multiple discriminant analysis, classification procedures, factor analysis. Prerequisites: Ed.Psy. 406 and 407, or Psy. 415.

512. Group Processes in the Classroom (2) Basic concepts and perspectives in the study of group processes; instructional group interaction; analysis of classroom behavior.

513. Individual and Group Differences (2) Historical and contemporary attempts to relate individual differences to important social and educational issues. Prerequisite: Ed.Psy. 400 or Psy. 15.

518. Contemporary Learning Models in Educational Psychology (3) Contemporary mathematical models and computer simulations of complex human learning occurring in school settings. Modes for analyzing the learning environment. Prerequisite: Ed.Psy. 421.

519. Psychological Foundations for College Teaching (2) Psychological, sociological, and organizational variables which influence college student behavior. Designed for graduate students who anticipate careers in college teaching.

522. Concept Learning in the Schools (2) Study of theory and research related to concept formation and attainment with implications for instruction. Prerequisite: Ed.Psy. 421.

523. Problem Solving in the Schools (2) Examination of theory and research related to cognitive processes in problem solving with implications for educational practice. Prerequisite: Ed.Psy. 421.

524. Theories of Learning and Instruction (3) Study of major classical theories of learning and recent developments in learning and instructional theory. Prerequisite: Ed.Psy. 421.

525. Application of Learning Models to Classroom Practices (2) Probabilistic models of acquistion in complex human learning; assessment of learning in the classroom that is amenable to such analysis. Prerequisite: Ed.Psy. 518.

532. Survey of Media Research (3) Systematic study of media research in educational applications of television, still and motion pictures, graphic and simulated environments. Prerequisite: Ed.Psy. 400 or Psy. 415.

550. Design and Construction of Psychological Measures (3) Lecture-practicum involving planning, construction, administration, and analysis of a psychological test; lectures stress construct validity, item analysis, and predictive validity. Prerequisite: Ed.Psy. 450.

554. Theories of Psychological Measurement (2) Basic true-score and error models; their extensions to test reliability and test validity; problems of item analysis and weighting. Prerequisite: Ed.Psy. 450.

575. Seminar in Educational Psychology (3-9) A seminar dealing with specific topics in educational psychology. Open to advanced students in the behavioral sciences.

591. Problems and Projects in Educational Psychology (1-6) Independent work on special topics.

ELECTRICAL ENGINEERING (E E)

William J. Ross, *Head of the Department*
118 Electrical Engineering East

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Adams, Bredeson, Brown, Cross, Das, Etzweiler, Ferraro, Hale, Holt, Lachs, Lee, Lewis, McMurtry, Mentzer, Nisbet, Quinn, Ross, and Volz.
Graduate Faculty: Associate Members Bishop, Delansky, Fonash, Hulina, Jeffreys, Robinson, and Trutt.

Course offerings and graduate research opportunities are available in the following areas: automatic control, biomedical engineering, computers, electromagnetics, energy conversion, information systems, ionosphere research, networks and circuits, plasmas, quantum electronics, and solid state electronics.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language. A thesis is required for the M.S. degree.

To be admitted to the M.S. program without undergraduate deficiency, a Bachelor of Science degree in Electrical Engineering, or its equivalent, is required with appropriate courses in electrical circuits, fields, and electronics. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 undergraduate grade-point average may be made for students with special backgrounds, abilities, and interests.

ELECTRICAL ENGINEERING (E E)

401. Network Analysis for Technology Teachers (3)
402. Electronic Devices and Circuits for Technology Teachers, Part I (3)
403. Electronic Devices and Circuits for Technology Teachers, Part II (3)
404. Electromechanical Energy Conversion for Technology Teachers (3)
405. Electronic Instrumentation for Nonelectrical Engineers and Scientists (3)
411. Principles of Electromagnetic Fields (3)
413. Linear Network Analysis (3)
417. System Theory (3)
418. Solid State Device Technology (3)
419. Solid State Devices (3)
421a,b,c,d. Electrical Engineering Problems (1-10)
423. Fundamentals of Industrial Electronics (3)
424. Fundamentals of Electrical Design (3)
425. Symmetrical Components (3)
428. Linear Control Systems (3)
429. Control System Design (3)
432. Microwave Methods and Analysis (3)
435. Engineering Analysis (3)
437. Engineering Applications of Complex Variables (3)
438. Antenna Engineering (3)
441. Active Circuits (3)

448. Linear Electronic Design (3)
449. Digital Electronic Design (3)
450. Network Analysis (3)
459. Introduction to Statistical Theory of Communications (3)
461. Fundamentals of Power System Stability (3)
470. Electronic Analog Computers (3)
471. Logical Design of Switching Systems (3)
472. Introduction to Digital Subsystems (3)
490. (Nuc.E. 490) Introduction to Plasmas (3)
492. (Astro. 492) Space Astronomy and Introduction to Space Science (3)

514. Quantum Electronics (3) Quantization of electromagnetic fields; quantum statistics of attenuators and amplifiers; analysis of laser oscillators; Glauber P-representation; photon detection and coherence. Prerequisite: Phys. 561.

519. Semiconductor Devices (3) Characteristics and limitations of bipolar transistors, diodes, transit time and bulk-effect devices. Prerequisite: E.E. 419.

521. Advanced Electrical Engineering Problems (1-10)

523. Nonlinear Analysis (3) Transient and steady state analysis of nonlinear physical systems; phase plane analysis, iterative techniques, singular points, and subharmonics. Prerequisite: E.E. 435.

525. Symmetrical Components (3) Polyphase circuits and machines under unbalanced conditions of operation including effects of rotating machines upon distribution and transmission system performance; characteristics of phase converters and single-phase operation of polyphase systems. Prerequisite: E.E. 425.

527. Linear Control Systems (3) Continuous and discrete-time linear control systems; state variable models; analytical design for deterministic and random inputs; time-varying systems stability. Prerequisite: E.E. 428 or M.E. 455, E.E. 417.

528. Nonlinear Control and Stability (3) Design of nonlinear automatic control systems; phase-plane methods; describing functions; optimum switched systems; Liapunov stability; special topics in stability. Prerequisites: E.E. 428 or M.E. 455, E.E. 417.

529. Optimal Control (3) Variational methods in control system design; classical calculus of variations, dynamic programming, maximum principle; optimal digital control systems; state estimation. Prerequisite: E.E. 527.

530. Adaptive and Learning Systems (3) Adaptive and learning control systems; system identification; performance indices; gradient, stochastic approximation, controlled random search methods; introduction to pattern recognition. Prerequisite: E.E. 527.

532. Advanced Microwave Engineering (3) Theory of wave guides and discontinuities, resonant cavities, traveling wave oscillators and devices; interaction of fields with matter. Prerequisites: E.E. 432 and 411.

535. Engineering Analysis (3) Applications of mapping methods, series and integral representations to the solution of boundary value problems in electrical engineering. Prerequisite: E.E. 437.

536. Transform Methods in Linear Analysis (3) Analysis of linear systems by Laplace transform with emphasis on periodic nonsinusoidal forcing functions. Prerequisite: E.E. 435.

538. Electromagnetic Engineering (3) Electromagnetic fields using the Maxwell-Lorentz equations as applied to vector fields, special solutions to scattering, diffraction, and radiation problems. Prerequisite: E.E. 411.

539. Antenna Engineering (3) Boundary value problems of radiating structures, integral equation formulations, source excitation problems, reflector antennas. Prerequisites: E.E. 411, 438.

540. (Nuc.E. 540) Theory of Plasma Waves (3) Solutions of the Boltzmann equation; waves in bounded and unbounded plasmas; radiation and scattering from plasmas. Prerequisite: E.E. 490.

541. (Nuc.E. 541) PLASMA THEORY (3) Advanced topics in kinetic theory, fluctuation theory, microinstability, and turbulence. Prerequisite: E.E. (Nuc.E. 540) 540.

546. FIELD-EFFECT DEVICES (3) The physical background, characteristics and limitations of surface field-effect and junction field-effect devices and related structures. Prerequisite: E.E. 419.

547. DIELECTRIC DEVICES (3) Applications of insulator physics and devices based on insulator properties. Prerequisite: E.E. 419.

548. LINEAR INTEGRATED CIRCUITS (3) Design of monolithic, thin-film and hybrid linear integrated circuits; D.C., video, tuned, r.f. and microwave applications. Emphasis on reliability. Prerequisites: E.E. 418, 448.

550. NETWORK SYNTHESIS (3) Positive real functions, realizability conditions, synthesis of driving point immittances, synthesis of two-terminal pair networks, transfer function synthesis. Prerequisites: E.E. 437, 450.

560. STATISTICAL THEORY OF COMMUNICATIONS (3) Generalized harmonic analysis; the application of correlation and convolution to the detection of signals in noise; various special topics. Prerequisite: E.E. 459 or Math. 409.

561. INFORMATION THEORY (3) Mathematical measurement of information; information transfer in discrete systems; redundancy, efficiency, and channel capacity; encoding systems. Prerequisite: E.E. 459 or Math. 409.

562. DETECTION THEORY (3) Detection decision theory, Bayes and Neyman-Pearson criteria, optimal receivers, classical estimation theory, signal-noise representations, optimum linear signal parameters estimation. Prerequisite: E.E. 560.

566. (Cmp.Sc. 566) ALGEBRAIC CODING THEORY (3) Polynomial rings, galois fields, linear codes, cyclic codes, BCH codes, finite projective geometry cyclic codes, convolution codes, graph theoretic codes. Prerequisite: Cmp.Sc. 450 or E.E. 561.

569. SIMULATION OF BIOMEDICAL SYSTEMS (3) Simulation of biological and medical systems on analog and digital computers; direct electrical analogs; modeling techniques. Prerequisites: E.E. 470 or Cmp.Sc. 401 and Biol. 11.

570. ADVANCED ELECTRONIC ANALOG COMPUTERS (3) Advanced techniques of analog computation and simulation; machine and problem errors; nonlinear differential equations. Prerequisite: E.E. 470.

571. DIGITAL COMPUTERS: RECENT DEVELOPMENTS AND ADVANCED LOGIC (3) Advanced treatment of logical design; discussion of topics of current interest in the general area of digital computers. Prerequisite: E.E. 471.

572. DIGITAL SYSTEM DESIGN (3) Complete digital system design including specification, internal organization, and realization. Discussion of interaction among digital systems and subsystems. Prerequisite: E.E. 472.

580. RADIO WAVES AND THE IONOSPHERE (3) The magneto-ionic theory of ionospheric wave propagation; ray-optical approximations; determination of ionization profiles; full wave solutions; nonlinear and coupling effects. Prerequisite: E.E. 62 or 438 or Phys. 557.

581. CONSTITUTION OF THE IONOSPHERE (3) Properties of neutral and ionized atmosphere above 60 km; photochemical processes; solar, meteoric perturbations of the ionosphere; large-scale movements in ionization.

ELEMENTARY EDUCATION (EL ED)

DONALD R. CHIPLEY, *In Charge of Graduate Programs in Elementary Education*
159 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Bixby, Bliesmer, Brewer, Dwyer, Heilman, McAulay, Trueblood, and Zafforoni.
Graduate Faculty: Associate Members Alessandro, Alfke, Cartwright, Chipley, Dopyera, Palmer, Short, Shrigley, and Singh.

The graduate programs provide advanced professional preparation for early childhood and elementary school teachers, curriculum specialists, elementary supervisory personnel, elementary school principals, and elementary teacher education personnel.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign languages.

For admission 18 credits in elementary education and teaching experience are required. Students with a 2.75 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.75 grade-point average may be made for students with special backgrounds, abilities, and interests.

A candidate for an advanced degree in this major should check with his program adviser for courses which are applicable to a specific degree from those listed on pages 81-82 in this bulletin.

The Master of Education degree in elementary education is offered also at the Capitol Campus. Specific requirements may be found in the *Capitol Campus Catalog.*

ENGINEERING ACOUSTICS (E ACS)

JIRI TICHY, *Chairman of the Committee on Engineering Acoustics*
Applied Research Laboratory, Applied Science Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Arndt, Baker, Brown, Brubaker, Hayek, Johnson, Martin, Michael, Neubert, Pigott, Reethof, Rowlands, Skudrzyk, Snowdon, and Tichy.
Graduate Faculty: Associate Members Farwell, George, King, Lawther, Macaluso, Miller, Prout, Sibul, and Thompson.

The aim of this intercollege program is to enable the student interested in acoustics to obtain an integrated program of courses covering the fundamentals of acoustical science and the biological, communications, and engineering applications of acoustics.

Programs are arranged through a selection of appropriate courses offered by the several departments of science, engineering, and arts, as well as those specifically in the area of engineering acoustics.

Areas of concentration include acoustic signal processing, architectural and building acoustics, noise and vibration, physical acoustics, speech and hearing, and underwater acoustics. Thesis research in the various areas may be conducted in relevant departments and in the Applied Research Laboratory.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by competence in the use of computer language as well as a reading knowledge of a foreign language.

Entering students should hold a bachelor's degree in physics, biology, engineering, architecture, mathematics, or speech and hearing, or in a closely related field; and they should have had at least one year of physics and mathematics including integral calculus. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for

admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

ENGINEERING ACOUSTICS (E ACS)

401. General Acoustics (3)

500. Special Problems in Acoustics (1-6) Provides training in selected areas of acoustics by means of supervised investigations or studies. Prerequisite: Phys. 443.

501. Engineering Acoustics Seminar (1 per term) Recent developments and current research in engineering acoustics.

511. Underwater Sound Propagation (3) Theoretical and empirical treatment of sound propagation in the ocean, including effects of the environment, characteristics of targets, and transducers.

512. Sonar Engineering (3) Theoretical and empirical treatment of problems related to the use of underwater sound in target detection and ranging.

513. Modern Acoustic Signal Processing (3) Probability review, representation of signals, noise processes, optimum filtering, ambiguity functions, linear and nonlinear signal processing, application to sonar systems.

514. Electroacoustic Transducers (3) The theory, design, and calibration of passive, linear, reciprocal electroacoustic transducers for use in both air and water media. Prerequisite: Phys. 443.

515. Acoustics in Fluid Media (3) Wave propagation in stationary and moving fluids; acoustic radiation and scattering; standing waves in ducts and cavities. Prerequisites: E.Mch. 524A, Phys. 443.

ENGINEERING MECHANICS (E MCH)

Robert M. Haythornthwaite, *Head of the Department*
227 Hammond Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Davids, Hardenbergh, Hayek, Haythornthwaite, Hu, Jaunzemis, Kiusalaas, Mentzer, Neubert, Sharma, Vierck, and Zamrik.
Graduate Faculty: Associate Members Conway, Fonash, Kimmel, Llorens, and Queeney.

Graduate study is available in the following areas: (1) dynamics, including mechanics of rigid bodies, vibration, and stress waves; (2) mechanics of deformable bodies including elasticity, plasticity, viscoelasticity, and continuum mechanics; (3) mechanics of materials and structures including mechanical properties, plates and shells, and plastic analysis; (4) experimental mechanics including experimental stress analysis, photoelasticity, and experimental vibration.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

The entering student must hold a bachelor's degree in engineering or science and have satisfactorily completed undergraduate courses in mechanics. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

ENGINEERING MECHANICS (E MCH)

400. Advanced Strength of Materials (3) *Mr. Hu*

401. Elements of Vibrations (3) *Messrs. Davids and Vierck*
402. Applied and Experimental Stress Analysis (3) *Mr. Conway*
403. Mechanics of the Solid State (4) *Mr. Queeney*
404. Research in Engineering Mechanics (1-6) *Mr. Conway*
407. Elements of Computer Methods in Engineering (3) *Mr. Hardenbergh*
408. Elasticity and Engineering Applications (3) *Messrs. Jaunzemis and Kiusalaas*
409. Advanced Mechanics (3) *Mr. Hardenbergh*
410. Mechanics of Space Flight (3) *Mr. Hardenbergh*
412. Experimental Methods in Vibrations (3) *Mr. Neubert*
413. Plastic Analysis of Structures (3) *Mr. Haythornthwaite*
414. Elements of Material Science (3) *Mr. Kimmel*
421. Continuum Mechanics (3) *Messrs. Hu and Pytel*
422. Continuum Mechanics (3) *Messrs. Hu and Jaunzemis*
446. Mechanics of Viscoelastic Materials (3) *Mr. Sharma*

500. Advanced Mechanics of Materials (3-6) Strain energy methods; special problems in bending and torsion; curved bars, beams on elastic foundations; thick-walled cylinders, shrink-fit assemblies, and rotating disc; thin-walled pressure vessels; bending of thin plates; buckling of bars and plates. Prerequisite: E.Mch. 13. *Mr. Zamrik*

506. Experimental Stress Analysis (3) Experimental methods of stress determination including photoelasticity, stress coat and electric strain gauge techniques; stress analogies; strain rosettes for combined stress determinations. Prerequisite: E.Mch. 408 or 507. *Mr. Conway*

507. Theory of Elasticity and Applications (3) Equations of equilibrium and compatibility; stresses and strains in beams, curved members, rotating discs, thick cylinders, torsion and structural members. Prerequisite: E.Mch. 13. *Mr. Kiusalaas*

508. Theory of Elastic Stability and Applications (3) Buckling of slender and short members; buckling of I-beams; stability of thin-walled constructions; thin-walled cylinders subjected to external pressures; applications to structural parts including aircraft members. Prerequisites: E.Mch. 12, 13. *Mr. Kiusalaas*

509. Theory of Plates and Shells (3) Bending and buckling of plates; elastic foundations; deformation of shells, multilayer shells, stress and stability analysis, weight optimization, application problems. Prerequisite: E.Mch. 13. *Mr. Kiusalaas*

514. Engineering Mechanics Seminar (1 per term) Current literature and special problems in engineering mechanics. *Staff*

516. Mathematical Theory of Elasticity (3) Fundamental equations and problems of elasticity theory; uniqueness theorems and variational principles; methods of stress functions and displacement potential; applications. Prerequisite: E.Mch. 540. *Mr. Hayek*

520. Advanced Dynamics (3) Dynamics of a particle and of rigid bodies: Newtonian equations in moving coordinate systems; Lagrange's and Hamilton's equations of motion; special problems in vibrations and dynamics. Prerequisites: E.Mch. 12, Math. 72 or 431. *Mr. Kiusalaas*

521. Stress Waves in Solids (3) Theoretical fundamentals, classic experiments; recent advances, including scabbing applications, plastic waves, penetration mechanics, impact, and numerical methods. Prerequisites: E.Mch. 12; Math. 405 or E.Mch. 524. *Mr. Davids*

522. Theory of Vibrations (3) Mathematical theory of vibrating systems; damping phenomena; forced vibrations; analogy between mechanical and electrical vibrations; transverse and torsional oscillation of shafts; vibration of strings, beams, membranes, and plates. Prerequisites: E.Mch. 13, Math. 72 or 431. *Messrs. Vierck and Neubert*

523. Computer Methods in Engineering Analysis (3) Finite elements, finite differences, and matrix methods applied to dynamics, elasticity, wave propagation, heat conduction, structural analysis, and fluid flow. Prerequisites: Cmp.Sc. 401, Math. 72. *Mr. Davids*

524. Mathematical Methods in Engineering (3 per unit) Prerequisite: A.M. 451 or E.E. 435 or M.E. 452. *Mr. Hayek*

Unit A (3) Basic tools, including Fourier, Legendre, and other orthogonal series, special functions, Laplace transforms. Applications in mechanics and other fields. Prerequisite: Math. 73.

Unit B (3) Solution techniques for boundary-value problems in curvilinear coordinates, integral transforms. Green's functions, potentials, applications to diffusion, vibration, wave-propagation. Prerequisite: E.Mch. 524A or Math. 431.

525. VIBRATION AND SHOCK IN DAMPED MECHANICAL SYSTEMS (3) Rubberlike materials; vibration isolation; structural impedance; wave propagation; multiforce excitation of beams; Timoshenko beams; transients; shock spectra; damage; nonlinear response. Prerequisite: E.Mch. 401 or 522. *Mr. Snowden*

526. NONLINEAR MECHANICS (3) Integral curves, singular points, self-sustained oscillations, stability problems, Hill's and Van der Pol's equation, mechanical and electrical application. Prerequisite: E.Mch. 522. *Mr. Neubert*

527. STRUCTURAL DYNAMICS (3) Dynamic behavior of structural systems; normal modes; input spectra; finite element representation of frameworks, plates, and shells; impedance; elastic-plastic response. Prerequisites: E.Mch. 12, 13. *Mr. Neubert*

528. EXPERIMENTAL METHODS IN VIBRATIONS (3) Investigation of one or more degrees of freedom, free and forced mechanical vibrations, vibration properties of materials, nondestructive testing. Prerequisite: E.Mch. 401 or 522. *Mr. Neubert*

530. SOLID STATE MECHANICS (3) Relation between solid state physics and mechanics; mechanical properties for static, fatigue, creep, and impact conditions; high temperature properties; applications. Prerequisite: E.Mch. 14. *Mr. Hu*

531. THEORY OF PLASTICITY AND APPLICATIONS (3) Yield condition; plastic stress-strain relations; theory of slip-line fields; applications to bending, torsion, axially symmetric bodies, metal processing. Prerequisite: E.Mch. 507. *Mr. Hu*

533. DETERMINATION OF MECHANICAL PROPERTIES (3) Experimental methods for determining hardness, elastic constants, creep behavior, fatigue strength, plastic flow, and dynamic properties of metals. Prerequisite: E.Mch. 14 or 530. *Mr. Zamrik*

534. PHOTOELASTICITY (3) Analysis of polariscopes; isoclinics, isochromatics, and stress trajectories; two- and three-dimensional photoelastic methods; determination of principal stresses; model preparation. Prerequisite: E.Mch. 408 or 507. *Mr. Conway*

535. (Metal. 535) CRYSTAL DEFECTS AND MECHANICAL RESPONSE (3) Mechanical responses of crystalline solids containing point, line, and interfacial defects; elastic and plastic responses. Prerequisite: Metal. 514 or E.Mch. 414. *Mr. Queeney*

540. INTRODUCTION TO CONTINUUM MECHANICS (3) Algebra and analysis of tensors; balance equations of classical physics; the linear theories of continuum mechanics. *Mr. Jaunzemis*

541. NONLINEAR THEORIES OF CONTINUUM MECHANICS (3) The general theory of constitutive equations; finite deformations and elasticity; flow and fluidity; viscoelasticity, modern topics. Prerequisite: E.Mch. 540. *Mr. Jaunzemis*

546. THEORY OF VISCOELASTICITY AND APPLICATIONS (3) Linear and nonlinear viscoelastic theories; generalized isotropic and anisotropic viscoelastic stress-strain relations. Prerequisite: E.Mch. 507. *Mr. Sharma*

550. STUDIES IN ENGINEERING MECHANICS (1-6) Studies in any field of engineering mechanics.

570. RANDOM VIBRATIONS IN STRUCTURAL MECHANICS (3) Probability theory applied to random vibrations of linear and nonlinear systems; excitation by ground motion, turbulence, and noise; acoustic damping. Prerequisite: Aersp. 411 or E.Mch. 401 or 522. *Mr. Neubert*

ENGINEERING SCIENCE (E SC)

LESLIE C. HALE, *Chairman of the Engineering Graduate Committee for Off-Campus Programs*
303 Electrical Engineering East

Degree Conferred: M.Eng.

A program leading to the degree of Master of Engineering with a major in engineering science is offered at the Behrend and King of Prussia Graduate Centers and at the Capitol Campus near Harrisburg. Details of the program may be obtained by writing directly to these locations. Addresses are given in the front of this bulletin.

The program is designed to provide a broad, advanced education in the engineering sciences with some specialization permitted in the area of a student's major interest. It is offered specifically to permit practicing engineers to pursue advanced studies through evening classes while in full-time employment in industry in the area. Courses offered for the program are all established and controlled by the resident departments at the University Park Campus.

The credit requirements in this major will be satisfied by an appropriate combination of core courses and elective courses. The core courses include offerings in mathematics and in several branches of engineering which have been selected because of their general character and breadth of applicability to all fields of engineering.

A minimum of 33 credits is required of which at least 12 must be at the 500 level. A scholarly written report is also required. Three of the above credits may be applied to this report.

Students may be admitted to the program from a wide variety of disciplines. Students applying for admission are expected to have completed the following core of previous student experience: (1) physics through modern physics, (2) mathematics through differential equations, (3) one course in engineering thermodynamics, (4) one course in electrical circuits, and (5) basic courses in engineering statics and dynamics. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Further details regarding admission requirements are available from the directors of the graduate campuses offering the program.

ENGLISH (ENGL)

DAVID H. STEWART, *Head of the Department*
117 Burrowes Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty: Senior Members Austin, Begnal, Condee, Frank, Jewkes, Lewis, Meserole, Price, Reed, Rosenberg, Rubin, Sams, Stewart, Weintraub, West, and Young.
Graduate Faculty: Associate Members Arnold, Borklund, Buckalew, Crane, Fitzgerald, Gidez, Grecco, Hudspeth, Lougy, Mann, Rogers, Secor, Shedd, Smith, and Walden.

A student may specialize in English literature, American literature, philology, or rhetoric. It is preferred that an entering student present 24 credits in English, but 18 credits in English exclusive of survey and freshman courses will be accepted. If the student does not present 18 credits in English, he must make up the deficiency early in his graduate work. A thesis is required of all M.A. candidates in this major.

The communication and foreign language requirement for the Ph.D. degree may be met by successful performance in any one of the following options: (1) critical and scholarly competence in one area of the literature of a foreign language; (2) reading, writing, and speaking knowledge of one foreign language; (3) reading knowledge of two foreign languages; or (4)

reading knowledge of one foreign language and demonstrated competence (normally by successful course work) in a technique such as computer science, statistics, etc., where relevant to the student's research interest.

Students with a 3.20 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.20 grade-point average may be made for students with special backgrounds, abilities, and interests.

ENGLISH (ENGL)

406. History of the English Language (3) *Messrs. Buckalew, Crane, and Shedd*
407. History of the English Language for Teachers (3) *Messrs. Buckalew, Moore, and Shedd*
408. Advanced College Grammar (3) *Mr. Kiffer*
411. Problems of Style (3)
412. The Writing of Fiction (3-6) *Messrs. Klass, Rogers, Rubinstein, and West*
413. Verse Writing (3-6) *Mr. Haag*
414. Biographical Writing (3) *Mr. Weintraub*
415. Nonfiction Writing (3) *Mr. Klass*
418. Advanced Technical Writing and Editing (3-6) *Messrs. Damerst and Houp*
422. Masters of British Literature (3-6) *Staff*
423. History of British Literature (3) *Staff*
424. Movements in British Literature (3) *Staff*
432. Masters of American Literature (3-6) *Staff*
433. History of American Literature (3)
434. Movements in American Literature (3-6) *Staff*
435. The American Short Story (3) *Messrs. Hudspeth, Levy, and Schneeman*
437. American Poetry (3) *Messrs. Gidez and Rubin*
438. American Drama (3) *Mr. Grecco*
441. Poetry and Prose of the Early Seventeenth Century (3) *Messrs. Arnold, Condee, and Kiernan*
442. Poetry and Prose of the Late Seventeenth Century (3) *Mr. McAdams*
443. Jacobean and Caroline Drama (3) *Messrs. Arnold and Jewkes*
444. Shakespeare: the Genres (3) *Staff*
445. Chaucer (3) *Staff*
446. Milton (3) *Messrs. Condee, McAdams, and Moore*
447. The Elizabethan Renaissance (3) *Messrs. Price and Reed*
448. English Drama Before Shakespeare (3) *Messrs. Jewkes and Moore*
449. Studies in Shakespeare (3) *Staff*
450. Readings in English (1-6) *Staff*
451. Poetry and Prose of the Early Eighteenth Century (3) *Mr. Fitzgerald*
452. Poetry and Prose of the Late Eighteenth Century (3) *Mr. Buck*
455. The Novel in England to Jane Austen (3) *Mr. Fitzgerald*
458. The Drama from Dryden to Sheridan (3) *Mr. Rogers*
461. British Nonfictional Prose of the Nineteenth Century (3) *Miss Austin*
462. Wordsworth and Coleridge (3) *Mr. Lougy*
463. Byron, Shelley, and Keats (3) *Miss Austin and Mr. Byrns*
465. Victorian Novel (3) *Miss Austin, Messrs. Goodwin and Lougy*
466. The American Novel to 1900 (3) *Messrs. Gidez and Secor*
467. Victorian Poetry (3) *Mr. Lougy*
470. Literature of the British Commonwealth (3) *Mr. Mann*
475. Modern British Fiction (3) *Messrs. Crane, Maxwell, and West*
476. The American Novel Since 1900 (3) *Mr. Young*
477. British and American Poetry of the Twentieth Century (3) *Mrs. Rodgers and Mr. Haag*
478. British and Irish Drama Since 1890 (3) *Mr. Grecco*
481. History of English Literary Criticism (3) *Messrs. Borklund and Stewart*

488. (C.Lit. 488) Modern Continental Drama (3) *Mr. Grecco*
490. Rhetorical Theory and Practice (3) *Messrs. Holahan and Rubinstein*
491. Literature for Teachers in Secondary Schools (3) *Messrs. Goodwin and Knapp*
*498. English Institute (6-12)

501. Materials and Methods of Research (4) Materials and techniques of research in English and American literary history; form and content of theses. Required of all graduate students with an English major. *Mr. Meserole*

520. The Middle English Romance (3) A detailed study of the Middle English metrical romance in terms of its milieu and its genre in the West. *Mr. Rosenberg*

521. Old English Language (3) An introduction to the main features of the Old English language; readings in simple Old English prose and poetry. *Mr. Buckalew*

522. Beowulf (3) Reading and critical analysis. Prerequisite: Engl. 521. *Mr. Buckalew*

523. Wordsworth and Coleridge (3) Major and some minor works; the pertinent criticism and scholarship; aspects of the period.

524. Byron and Shelley (3) Major and some minor works; the pertinent criticism and scholarship; aspects of the period. *Miss Austin*

525. Blake and Keats (3) Major and some minor works; the pertinent criticism and scholarship; aspects of the period. *Miss Austin*

526. Tennyson and Browning (3) *Mr. Lougy*

536. Henry James (3) The development of James as critic, novelist, and short story writer. *Mr. Borklund*

537. Robinson and Frost (3) The art and thought of two American poets who link the traditions of the nineteenth and twentieth centuries.

540. Studies in Elizabethan Prose and Poetry (3-6) *Messrs. Price and Reed*

541. Medieval Studies (3-6) Special problems in medieval English literature. *Messrs. Frank and Rosenberg*

542. Middle English Literature (3) Introduction to Middle English and its dialects; study of the literature of the period exclusive of Chaucer. *Mr. Crane*

543. Studies in Early Seventeenth Century Literature (3-6) Major poets and prose writers from 1600 to 1660. *Mr. Condee*

544. Restoration Literature (3) Selected studies of writers in England between 1650 and 1700. *Mr. Fitzgerald*

545. Chaucer (3-6) Critical study of the *Canterbury Tales* or *Troilus and Criseyde* and minor poems. *Messrs. Frank, Rosenberg, and Shedd*

546. Milton (3) The poetry and prose of John Milton. *Mr. Condee*

548. Elizabethan and Jacobean Drama (3-6) English drama from 1558 to 1642 exclusive of Shakespeare. *Mr. Jewkes*

549. Shakespeare (3-6) Special problems of sources, chronology, text, characterization, and motivation in the drama. *Messrs. Jewkes, Price, and Reed*

552. Swift and Pope (3) *Mr. Sams*

553. The Age of Johnson (3) The work of Johnson and his circle. *Mr. Fitzgerald*

554. Studies in Early American Literature (3) *Mr. Meserole*

555. The Puritans (3) Critical studies of the principal works of English and American Puritans.

556. Eighteenth Century British Fiction (3) *Messrs. Fitzgerald and Sams*

557. Early Eighteenth Century British Literature (3) Prose and poetry in the reign of Queen Anne, with special attention to periodical publications. *Mr. Sams*

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*A maximum of 6 credits in one summer.

560. American Romanticism (3) The Romantic movement in American literature of the mid-nineteenth century. *Messrs. Hudspeth and Secor*

561. Studies in the Romantic Movement (3-6) *Miss Austin*

562. Studies in the Literature of Victorian England (3-6) *Miss Austin and Mr. Weintraub*

564. Studies in Nineteenth Century American Literature (3) The major figures treated will vary from year to year. *Messrs. Gidez, Rubin, and Secor*

573. Studies in Twentieth Century British Literature (3-6) Major writers and literary movements. *Messrs. Crane, Weintraub, and West*

574. Studies in Twentieth Century American Literature (3-6) Major writers and literary movements. *Mr. Young*

575. James Joyce (3-6) Alternate terms: *Ulysses* and *Finnegans Wake.* Knowledge of *Dubliners* and *A Portrait of the Artist* is assumed. *Mr. Begnal*

576. Hemingway and Faulkner (3) The major works. *Messrs. Crane and Young*

578. Shaw (3) The plays, prose writings, and literary influence of G.B.S. *Mr. Weintraub*

579. T. S. Eliot (3) Major works in poetry, criticism, and drama; pertinent scholarship and criticism.

581. Contemporary Literary Criticism (3) *Messrs. Borklund, Sams, and Stewart*

582. Hawthorne and Melville (3) Detailed study of the major works of both authors and of the relationship between the two men. *Messrs. Gidez and Young*

583. Emerson and Thoreau (3) The significant prose and poetry of the chief American transcendentalists. *Mr. Hudspeth*

584. Whitman and Dickinson (3) The major texts, with special emphasis on background and language. *Mr. Rubin*

585. Twain and Howells (3) The principal works, the relationship between the two men, and their place in American literature.

586. Readings in Literature (1-12) Programs of readings designed to meet specific needs of individual students. *Staff*

587. Franklin and Edwards (3) Studies in the lives, works, and milieu. *Mr. Meserole*

588. Studies in American Fiction (3-6) *Messrs. Gidez and Rubin*

589. Studies in American Poetry (3-6) *Messrs. Borklund and Rubin*

592. Studies in American Literary Myth (3) An introduction to an interpretive, interdisciplinary study of some representative themes in American literature and culture. *Mr. Young*

593. (C.Lit. 593) Anglo-American Folk Song (3) Survey of relevant literary and ethnological scholarship and field work, European and American, from the early sixteenth century to the present.

595. Studies in British Fiction (3-6) *Messrs. Crane and Weintraub*

ENTOMOLOGY (ENT)

Beckford F. Coon, *Head of the Department*
102 Patterson Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members Asquith, Benton, Coon, Kim, Mumma, Rutschky, Smyth, Snetsinger, and Yendol.
Graduate Faculty: Associate Members Ercegovich, Hower, and Smilowitz.

A student majoring in entomology may specialize in various areas of economic entomology and in forest entomology, apiculture, insect resistance in plants, arachnology, medical or veterinary

entomology, biological control, insect pathology, insect transmission of plant pathogens, ecology, morphology, embryology, taxonomy, physiology, insect behavior, or chemistry of pesticides.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by one foreign language and proficiency in English.

For admission a student is required to have 24 credits in entomology and related biological and physical sciences. Chemistry through organic, physics, mathematics, and statistics are advantageous. A limited deficiency may be made up, without degree credit, while pursuing graduate work.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

ENTOMOLOGY (ENT)

401. Medical and Veterinary Entomology (3) *Mr. Kim*
409. Insect Biology and Management (3) *Mr. Rutschky*
412. Field Entomology (3) *Mr. Rutschky*
414. Insect Morphology and Phylogeny (3) *Messrs. Kim and Rutschky*
415. Insect Physiology and Biochemistry (3) *Messrs. Mumma and Smyth*
416. Insect Ecology and Control (3) *Messrs. Cameron and Hower*
418. Forest Entomology (3)
431. Special Problems (1-6)
435. Arachnology (3) *Mr. Snetsinger*

515. Insect Morphology and Systematics (1-3) Current theories, controversies and advanced techniques in comparative morphology, histology, embryonic and postembryonic development, taxonomy and systematics of insects. Winter term.

516. Insect Physiology and Biochemistry (1-3) Selected topics in insect function and metabolism. Fall term.

517. Insect Ecology and Behavior (1-3) Selected aspects of the biotic and abiotic interactions of insects. Winter term.

518. Pest Management (1-3) Current concepts and controversies in modern agricultural and urban pest management practice. Spring term.

531. Insect Toxicology (2) General principles of toxicology and survey of the actions of substances toxic to insects. Fall term, odd years.

532. Insect Behavior (2) Orientation reflexes, learning, communication, and social behavior; physiological bases, ecological and evolutionary implications. Summer term, odd years.

535. Biological Control (3) Practical and theoretical aspects of arthropod control by entomophagous insects and the place of biocontrol in integrated control programs. Winter term, even years.

536. Insect Pathology (3) Diseases of arthropods and some aspects of microbial control of insects. Prerequisite: Micrb. 1. Winter term, odd years.

542. (Biol. 542) Systematics (3) Principles and methods of classification, phylogeny and speciation; taxonomic techniques; analysis of species, causal interpretation of animal diversity. Fall term.

ENVIRONMENTAL POLLUTION CONTROL (EPC)

WILLIAM J. MOROZ, *In Charge of Graduate Programs in Environmental Pollution Control*
226 Chemical Engineering Building II

Degrees Conferred: M.S., M.Eng., M.E.P.C.

Graduate Faculty: Senior Members Aplan, Eagleton, Heicklen, Hunt, Langmuir, Moroz, Nesbitt, and Watrous.

This intercollege program deals with the various aspects of the control of air and water pollution and the disposal of solid wastes. Graduate instruction is under the direction of an interdisciplinary faculty committee and the departments participating in the program. The faculty consists of the committee members listed above and a larger group of graduate faculty members with a teaching and/or research interest in the area of environmental pollution control.

Students are required to pass 9 credits of core courses: C.E. 472, Water Pollution Control; C.E. 476, Solid Waste Management; and M.E. 470, Introduction to Air Pollution Control. In addition, they must select at least 21 of their total credits from a recommended course list and schedule the environmental pollution control seminars (590) for three terms. A thesis is optional. If the option to prepare a thesis is selected, the topic must be in the area of environmental pollution control and at least 6 credits of research must be taken in the department in which the student is affiliated.

Admission to the program will be granted upon recommendation of the academic department in which the student plans to follow his studies and the Environmental Pollution Control Program Faculty Committee. Normal admission requirements are mathematics through integral calculus plus one year's work in general physics and chemistry. Students with a 2.50 junior-senior average and with appropriate backgrounds in mathematics and science will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

EXTENSION EDUCATION (EXTED)

WILLIAM M. SMITH, JR., *Chairman of the Committee on Extension Education*
105 Weaver Building

Degrees Conferred: M.Agr., M.Ed.

This program is designed primarily to meet the needs of professional teachers in various extension and adult education positions. The purpose is to train individuals to develop attitudes, understandings, and competences which enable them to become more effective professional workers. Options have been developed for the College of Agriculture. Additional options will be offered as they are developed by other colleges.

For either degree a minimum of 30 credits is required, in addition to a professional paper. These credits should be distributed as follows: 12 credits in extension core courses, 6 in communication and/or education, and 12 in two areas of agriculture and/or home economics.

Admission requirements include a strong background in agriculture or home economics and a minimum of 12 credits in the social sciences. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

FOOD SCIENCE (FD SC)

DONALD V. JOSEPHSON, *Chairman of the Division of Food Science and Industry*
111 Borland Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Dimick, Josephson, Keeney, Kroger, MacNeil, McArdle, McCarthy, Patton, Sink, Thompson, Watrous, and Ziegler.
Graduate Faculty: Associate Members Beelman, Glass, and Kuhn.

Opportunities are available for study in the fields of dairy products, meats, fruits and vegetables, and poultry products. Special emphasis can be devoted to food chemistry, microbiology, quality control, flavor control and acceptance, rheology, processing, packaging, and distribution.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language or through approved technical writing and speech courses.

Prerequisite to graduate work is the completion of an undergraduate degree in food science, biochemistry, microbiology, or another related area. The undergraduate program must include calculus, organic chemistry, microbiology, and general physics. Students may be admitted with deficiencies but are required to make them up without degree credit. Students who present a 2.75 junior-senior average will be considered for admission to the program subject to the limitations of the physical facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

FOOD SCIENCE (FD SC)

400. EFFECTS OF PROCESSING ON FOODS (3)
402. THE THERMAL PROCESS (1)
403. SANITATION AND QUALITY CONTROL (3)
404. SENSORY EVALUATION OF FOODS (2)
410. CHEMICAL METHODS OF FOOD ANALYSIS (4)
421. TECHNICAL CONTROL PROBLEMS (1-6)

505. CONCEPTS OF PRODUCT DEVELOPMENT (3) Interrelationships of processing principles and chemical and physical properties in the development of new and improved food products.

507. FOOD QUALITY, FOOD STANDARDS, AND CONSUMER PROTECTION (2) Problems of the food industry relating to contamination and quality of food products.

510. SEMINAR IN FOOD SCIENCE (1-6)

520. PROBLEMS IN FOOD SCIENCE (1-9) Special problems in dairy, horticultural, meat, poultry, and other food products.

522. RESEARCH PROCEDURES IN FOOD SCIENCE (3) Research problems and methods in food science with major emphasis on food chemistry.

In addition to the courses listed above, the following courses are available in food science; their descriptions may be found under the offerings of the cooperating departments: A.I. 421, 431, 502; Ag.E. 412, 413, 414, 423, 503; D.Sc. 427, 521; Hort. 528; Micrb. 414; Pty.Sc. 504.

FOREST RESOURCES (FOR R)

WILBER W. WARD, *Director of the School of Forest Resources*
101 Ferguson Building

Degrees Conferred: Ph.D., M.S., M.F.

Graduate Faculty: Senior Members Borden, Fletcher, George, Gerhold, Hutnik, Murphey, Shipman, Sopper, and Ward.
Graduate Faculty: Associate Members Anthony, Baldwin, Beall, DeWalle, Kersavage, Lindzey, Turner, and Wood.

The Doctor of Philosophy and the Master of Science degree programs are oriented toward research, education, and scientific technology in the professions of forestry, wildlife management, and wood science. The foreign language requirement for the Ph.D. degree may be satisfied by demonstrating competence in one foreign language equivalent to passing three college-level courses.

The Master of Forestry is a professional degree which emphasizes applications of knowledge through managerial practices involving forest resources, industries, or the natural environments of communities and recreational areas.

A thesis is required for each of the degrees. Most programs of study are strengthened by including appropriate courses offered by related departments.

Faculty expertise, laboratories, and outdoor research facilities are available to support specialization in a variety of fields. Possibilities for specialization are indicated in part by the courses listed under forestry, wood science, and wildlife; also by related courses in agricultural economics, agronomy, animal nutrition, biology, business administration, chemical engineering, computer science, ecology, economics, entomology, environmental pollution control, environmental resource management, genetics, horticulture, industrial engineering, landscape architecture, meteorology, physiology, plant pathology, polymer sciences, recreation and parks, regional planning, or statistics.

To be considered for admission a student should have at least a 2.50 all-university average and 9 credits of basic biology; 12 credits of calculus, statistics, and computer science; 12 credits of chemistry and physics; 12 credits of communications; 12 credits of economics and social sciences or humanities; and 18 credits in forestry, wildlife, or wood science. Each applicant should arrange for three reference report forms to be sent and submit a brief statement describing his academic goals, career interests, and special qualifications for proposed studies. The best qualified applicants will be accepted up to the number of spaces available. Exceptions to the 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

FORESTRY (FOR)

403. DENDROLOGY (3)
410. FOREST RESOURCES SEMINAR (1)
416. FOREST RECREATION (3)
421. SILVICULTURE (3)
427. FOREST RANGE MANAGEMENT (3)
440. FOREST ECONOMICS AND FINANCE (3)
450. ADVANCED MENSURATION (3)
455. AERIAL PHOTOS IN FORESTRY (3)
466. FOREST RESOURCE MANAGEMENT (3)
480. POLICY AND ADMINISTRATION (3)
497. PROBLEMS IN FORESTRY (1-6 per term)

508. ADVANCED FOREST ECOLOGY (3) Organization, development, and classification of forest communities. Prerequisite: For. 308.

509. Wildlife Habitat Management (3) Management of forest associations for maintenance and development of wildlife. Prerequisite: For. 508 or Biol. 516.

512. Forest Genetics (3) Theoretical and practical application of genetics to forestry; experiments in genetic variation, breeding, progeny testing, and vegetative propagation of trees. Prerequisite: Biol. 22.

517. Forest Microclimatology (3) Forest microclimatology quantitative treatment of climate near the ground, with special reference to the role of forests and terrain. Prerequisite: Phys. 202.

519. Forest Hydrology (3) Influence of forest cover on the disposition of precipitation and the application of hydrologic principles and techniques to forest watersheds. Prerequisites: For. 308, C.E. 51.

521. Advanced Silviculture (3) Specific silvicultural practices for the establishment and manipulation of forest stands with respect to recent developments and research needs. Prerequisite: For. 421.

525. Forest Land Use Alternatives (3) Recognition and analysis of various compatible and conflicting uses of forest land as a component of rural land. Prerequisites: For. 466, Ag.Ec. 421 or Geog. 405, 3 credits in statistics.

550. Design and Analysis of Experiments (3) Specialized techniques involved in the design and analysis of complex forestry research problems. Prerequisite: For. 450.

560. Timber Management (3) Technical methods in the organization and control of the forest property for timber production.

575. Applications of Forest Economics and Finance (3) Survey of situations in forestry where business problems and particular circumstances of production, value, and costs are currently significant. Prerequisite: For. 440.

WOOD SCIENCE (W S)

411. Physical Properties of Wood (3)
412. Mechanical Properties of Wood (3)
413. Chemical Properties of Wood (3)
414. Pulp and Fiber Technology (3)
420. Processing and Machining of Wood (2)
421. Adhesives and Finishes for Wood Products (2)
422. Seasoning and Preservation (2)
430. Forest Products Manufacturing Systems and Standards (3)
469. Problems in Wood Science (1-6)
491. Logging and Lumbering (3)
495. Forest Products Production Management (3)
497. Small Sawmills (3)

502. Wood Fibers (3) Identification and physical and chemical characteristics of wood fibers used for pulp, either for paper or as a source of cellulose; pulping quality, fiber measurements.

511. Wood-Fluid Relationships (3) Treatment of adsorption equations, thermodynamics, and diffusion through wood. Prerequisite: W.S. 337.

513. Wood Chemistry (3) Treatment of the chemical components of wood, their distribution and reactions. Prerequisite: W.S. 413.

531. Mechanical Behavior of Wood (3) Time-dependent properties, theory of failure, rheologic properties, and theory of the mechanical behavior of wood and structural composites.

532. Theory of Adhesion (3) Theory of adhesion as it pertains to bonding of wood, paper-based laminates, fibers, and bonding of wood to dissimilar materials.

595. Forest Products Industrial Operations Analysis (3) Applications of operations research methods in the forest products industry; mathematical programming, simulation, waiting line problems, sequencing. Prerequisite: W.S. 495.

FRENCH (FR)

RICHARD L. FRAUTSCHI, *Head of the Department*
S-404 Burrowes Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Belasco, Brault, Chapman, Frautschi, Hyslop, and LeSage.
Graduate Faculty: Associate Members Anderson, Armitage, Knight, Norton, Tinelli, and Ward.

A student may follow a graduate program in French literature, descriptive and historical linguistics, francophone culture, and language acquisition with a minor in a related field. M.A. candidates may submit either a thesis or a term paper. If the latter is chosen, 6 additional credits in 500-level courses in the major program must be scheduled. The communication and foreign language requirement for the Ph.D. degree may be satisfied by at least an intermediate knowledge of two foreign languages other than French. For the D.Ed. and M.A. degrees an intermediate knowledge of one foreign language other than French is required.

The minimum requirement for admission to an advanced degree program will normally be 27 credits of post-intermediate work in language and literature. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. A brief tape recording must be presented before admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

FRENCH (FR)

417. FRENCH PHONOLOGY (3) *Mr. Tinelli*
418. FRENCH MORPHOLOGY AND SYNTAX (3) *Mr. Tinelli*
422. OLD FRENCH LITERATURE (3) *Mr. Knight*
426. FRENCH LITERATURE OF THE RENAISSANCE (3) *Mr. Morton*
430. CONTEMPORARY FRANCE (3) *Mr. LeBlanc*
435-436. SEVENTEENTH CENTURY FRENCH LITERATURE (3 each) *Mr. Chapman*
445. THE FRENCH NOVEL OF THE EIGHTEENTH CENTURY (3) *Mr. Anderson*
446. FRENCH DRAMA OF THE EIGHTEENTH CENTURY (3) *Mr. Anderson*
451-452. NINETEENTH CENTURY FRENCH LITERATURE (3 each) *Mrs. Hyslop*
460. FRENCH PROSE OF THE TWENTIETH CENTURY (3) *Mr. LeSage*
461. FRENCH POETRY AND DRAMA OF THE TWENTIETH CENTURY (3) *Mr. LeSage*
470. ADVANCED COMPOSITION AND CONVERSATION (3) *Mrs. LeBlanc*
471. ADVANCED STYLISTICS (3) *Mrs. LeBlanc*
480. THE TEACHING OF FRENCH (4) *Mr. LeBlanc*
491. PROBLEMS IN FRENCH LITERATURE (3-6) *Staff*
499. FOREIGN STUDY IN FRENCH (3) *Staff*

*1G. ELEMENTARY FRENCH FOR GRADUATE STUDENTS (3) Designed for students preparing to satisfy language requirements for advanced degrees.

*2G. ELEMENTARY FRENCH FOR GRADUATE STUDENTS (3) Continuation of Fr. 1G with reading practice.

500. AN INTRODUCTION TO OLD FRENCH (3) Analysis of the phonology, morphology, and syntax of the Old French language based on early literary monuments. *Mr. Brault*

503. FRENCH PHONOLOGY (3) Articulatory and acoustic correlates of distinctive features; synchronic dialectology; phonology in generative grammar. *Mr. Belasco*

*No graduate credit is given for this course.

504. FRENCH MORPHOLOGY AND SYNTAX (3) Principles of segmentation and decomposition; tagmemics and transformation theory; morphophonemics. *Mr. Belasco*

505. SEMANTIC THEORY OF THE FRENCH LANGUAGE (3) The goals of semantic description; systematic interrelation of semantic generalizations; empirical and methodological constraints. *Mr. Belasco*

516. THE SONG OF ROLAND (3) Seminar in the Old French *Chanson de Roland,* with emphasis on the problems of textual criticism and literary analysis. *Mr. Brault*

517. VILLON (3) The poetry of Villon with reference to the cultural and social context of the late medieval period. *Mr. Knight*

518. MEDIEVAL FRENCH DRAMA (3) The development of French drama from its liturgical origins to the flourishing comic theater of the late Middle Ages. *Mr. Knight*

526. RABELAIS (3) Seminar in works of François Rabelais, notably Book I (Pantagruel) and Book II (Gargantua), with emphasis on comic devices and narrative technique. *Mr. Norton*

527. FRENCH RENAISSANCE POETRY (3-6) Evaluation of French poetry from Marot through the Pléiade; emphasis on Ronsard and DuBellay. *Mr. Norton*

528. MONTAIGNE (3) Genesis and evolution of Montaigne's creation of the personal essay; influence of the *Essais* in seventeenth, eighteenth century French literature. *Mr. Norton*

533. SEVENTEENTH CENTURY PROSE AND POETRY (3) The development of Classicism; its apogee and decline as seen in the works of major prose writers and poets. *Mr. Chapman*

534. MOLIÈRE (3) The literary achievement of Molière, the comic playwright, director, actor, and founder of the Comédie Française. *Mr. Chapman*

535. SEVENTEENTH CENTURY FRENCH TRAGEDY (3) The development and triumph of tragedy as a literary genre with special emphasis on the achievement of Corneille and Racine. *Mr. Chapman*

536. LA FONTAINE (3) The literary artistry of La Fontaine with special emphasis on his contribution as a fabulist. *Mr. Chapman*

540. VOLTAIRE (3) The artistic and philosophical evolution of Voltaire as seen in the tragedy, the philosophical tale, and poetry. *Mr. Anderson*

541. ROUSSEAU (3) Rousseau's rationalistic critique of civilization; his sentimental rehabilitation of the individual, family, state; Rousseau precursor of Romanticism. *Mr. Anderson*

542. DIDEROT AND THE ENCYCLOPEDISTS (3) The literary *philosophe* in the Age of Enlightenment with special emphasis on Diderot and his collaborators on the *Encyclopédie. Mr. Frautschi*

561. FRENCH ROMANTICISM (3) The Romantic movement in French literature with emphasis upon its major exponents in prose and poetry. *Mrs. Hyslop*

563. FRENCH REALISM (3) The Realistic movement in French literature with emphasis upon its major exponents in prose and poetry. *Mrs. Hyslop*

565. THE NINETEENTH CENTURY FRENCH NOVEL (3) The development of the novel in the nineteenth century with emphasis on Constant, Balzac, Stendhal, Flaubert, and Zola. *Mrs. Hyslop*

567. TWENTIETH CENTURY FRENCH THEATRE (3) Evolution of the French theatre from the plays of the *belle époque* to the avant-garde works of today. *Mr. LeSage*

568. BAUDELAIRE (3) A study of his poetry and his criticism. *Mrs. Hyslop*

569. MASTERS OF TWENTIETH CENTURY FRENCH LITERATURE (3-6) Major literary figures of contemporary French literature. *Mr. LeSage*

571. FRENCH LITERARY CRITICISM FROM SAINTE-BEUVE TO PRESENT (3) Evolution of French literary criticism from Sainte-Beuve, the "father" of modern literary criticism, to contemporary critics. *Mr. LeSage*

580. SEMINAR IN FRENCH LITERATURE (3-12) Lectures on methods of research. Students will pursue common and individual investigations in fields selected after consultation with the instructor. *Staff*

581. Theory and Techniques of Teaching French (1-3) *Staff*

586. Symbolism (3) The anti-positivistic tradition in nineteenth-century French literature dealing with the Symbolist School; its antecedents and its subsequent ramifications. *Mr. Le-Sage*

587. Research Techniques and Bibliography in French Language and Literature (1-3) *Staff*

595. Analysis of French Civilization (3-6) French cultural aspects, other than language and literature, conducted in French with the collaboration of specialists outside the French department. *Mrs. Armitage*

FUEL SCIENCE (F SC)

HOWARD B. PALMER, *In Charge of Graduate Programs in Fuel Science*
320 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Austin, Essenhigh, Given, Palmer, Vastola, and Walker.
Graduate Faculty: Associate Member Becker.

This program is one of the options in which a graduate student in the Department of Material Sciences can receive an advanced degree.

Research facilities, well instrumented, are available for the study of high temperature gas reactions by shock-tube and other techniques, electrochemical kinetics of fuel cell and battery systems, reactions in plasmas and flames, physics and chemistry of carbons and graphites, fundamental processes in the industrial combustion of gaseous, liquid, and solid fuels, mass spectrometric investigation of the structure of solids, comminution of brittle materials, and the organic geochemistry of plant-derived sediments. Students can plan a wide variety of programs of study, to suit individual needs; coherent interdisciplinary programs are encouraged. The nonthesis option is available for the M.S. degree.

A basic minimum of 30 course credits is required for the Ph.D. degree, of which at least 12 must be in departmental courses. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Applications will be accepted from persons having backgrounds in chemistry or physics; chemical, mechanical, or aerospace engineering; material sciences; or earth sciences. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

FUEL SCIENCE (F SC)

400. Fuel Science Research and Design (1-10 per term)
410. Fuel Science Laboratory (1) *Staff*
421. Flames (3) *Mr. Becker*
422. Combustion Engineering (3) *Mr. Essenhigh*
423. Combustion Laboratory (1) *Mr. Essenhigh*
424. Energy in Space Travel (3) *Mr. Vastola*
431. The Chemistry of Fuels (3) *Mr. Given*

504. (Gchem. 504) Organic Geochemistry of Coal (3) Interdisciplinary study of accumulation of organic sediments and their metamorphism into coal macerals; effects of environment; structure of coal macerals. *Mr. Given*

506. Carbon Reactions (3) Current approaches to heterogeneous reactions in combustion and gasification of carbons and graphite. Prerequisite: Chem. 452. *Mr. Walker*

512. High Temperature Kinetics and Flame Propagation (3) Laminar and turbulent premixed and diffusion flames; gaseous detonations; rate processes in high temperature gases. Prerequisite: F.Sc. 421. *Mr. Palmer*

514. Jet and Rocket Fuels (2) Propulsion systems; combustion chamber conditions; liquid and solid propellants, slurries, fuel sprays, and finely divided solids. Prerequisite: F.Sc. 421. *Mr. Palmer*

Note: *Courses in the use of X-ray diffraction, electron microscopy, spectroscopy, and electronic instrumentation in fuel science studies are listed under Materials Science.*

GENERAL ENGINEERING (GEN E)

Otis E. Lancaster, *Chairman of the Committee on General Engineering*
101 Hammond Building

Degrees Conferred: M.Ed., M.Eng.

This program is designed primarily to give academic preparation to those individuals who will teach engineering subjects in technical institutes and two-year colleges.

For either degree a minimum of 30 credits is required in addition to a scholarly written report. Twenty-four of these credits should be in engineering, physics, and mathematics. A candidate is expected to earn at least 3 credits each in mathematics, physics, and two fields of engineering, or demonstrate competence in them.

For the M.Ed. 6 credits must be in education, consisting of one 3-credit course in the theory of learning and teaching and one 3-credit course in internship in college teaching. Fifteen credits must be earned at the 500 level.

For the M.Eng. degree 6 credits may be taken in any field approved by the committee, but at least 12 credits in engineering subjects must be at the 500 level.

For admission an undergraduate degree in engineering, physical science, mathematics, or the equivalent is required. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

GENETICS (GENET)

Edward G. Buss, *Chairman of the Committee for Genetics*
203 Animal Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Buss, Cleveland, Dalton, Davidson, Deering, Fritz, Gerhold, Ginoza, Goodwin, Grun, Hunt, Jones, Keith, Marshall, R. Nelson, O'Mara, Person, Rake, Rapp, Snipes, Starling, Therrien, Todd, Vesell, Walker, Wilson, Wright, and Zimmerman.
Graduate Faculty: Associate Members Ayers, Barnes, Brenchley, Craig, Dyke, Eckardt, Funk, Hargrove, Hepler, C. W. Hill, R. N. Hill, Johnson, Lausch, MacCluer, Pfeifer, Risius, Shenk, and Thoele.

The program for genetics is an intercollege one, and faculty from the Colleges of Agriculture, Liberal Arts, Medicine, and Science serve as major advisers and on committees for the majors. The student is encouraged to select his major adviser.

Opportunities for graduate study and research are available in biochemical, developmental, microbiological, viral, molecular, population, cytogenetics, and pharmacogenetics. Organisms

available for research include fungi; bacteria; viruses; fish; amphibia; rodents; birds; man; grain, forage, and horticultural plants; and forest trees. The graduate faculty committees for majors have the responsibility and jurisdiction for determining course work, specific requirements in communication skills exceeding the minimum, and research acceptable for satisfying degree requirements. The requirement in communication and foreign language skills for the Ph.D. degree may be satisfied by fulfilling the requirement of the thesis adviser's department or program.

Students with a grade-point average of 3.00 or better and with appropriate course backgrounds in biology, science, and communications courses will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Students with limited deficiencies may be admitted, but they must make up such deficiencies concurrently with their graduate studies.

The following genetics courses are available: Agro. 411, 509, 510; An.Sc. 422, 455; Biol. 405, 422, 426, 427, 428, 528; B.Chem. 503; Bphys. 430; C.Med. 503; For. 512; Hort. 407, 444, 507; Micrb. 516, 553, 556; Pharm. 515, 540; P.Path. 543. Twelve credits in these courses and 1 credit in genetics seminar are required for the M.S. degree in genetics or a minor in genetics for a Ph.D.; 15 credits in these courses and 3 credits in genetics seminar are required for a Ph.D. major in genetics. Transfer credits for courses in genetics may be accepted as substitutes for the above listed courses.

GEOCHEMISTRY (GCHEM)

ARTHUR L. BOETTCHER, *In Charge of Graduate Programs in Geochemistry*
211 Deike Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Barnes, Bates, Boettcher, Burnham, Dachille, Griffiths, Keith, Langmuir, Muan, Newnham, Rose, Roy, Smith, Thornton, White, and Wickman.
Graduate Faculty: Associate Members Deines, Kerrick, Ohmoto, and Suhr.

Areas of specialization include crystal chemistry, phase equilibria, element distribution and affiliations, isotope geochemistry, geochemical exploration, cosmochemistry, high-temperature and high-pressure geochemistry, and solid state technology.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages or by comprehensive knowledge of one. The nonthesis option is available for the M.S. degree.

Before starting graduate study, an applicant is generally expected to have had a standard introductory course in each of the following four subjects — chemistry, physics, geology, and mineralogy; 12 credits of intermediate-level work in any one or a combination of chemistry, physics, and geological science; and mathematics through integral calculus. Students who have taken somewhat less than the indicated minimum of subjects may be admitted but must make up their deficiencies concurrently with their graduate studies.

Students who present a 2.70 grade-point average in their basic science and geoscience subjects and other appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the 2.70 grade-point average may be made for students with special backgrounds, abilities, and interests.

GEOCHEMISTRY (GCHEM)

402. INTRODUCTION TO ORGANIC GEOCHEMISTRY (3) *Mr. Given*
457. GEOCHEMICAL EXPLORATION (3) *Mr. Rose*

502. (Geol. 502) Carbonates in the Marine Environment (3) Ancient carbonate rocks and recent carbonate sediments, with emphasis on modern field and laboratory methods and a multidisciplinary approach. *Mr. Weber*

504. (F.Sc. 504) Organic Geochemistry of Coal (3) Interdisciplinary study of accumulation of organic sediments and their metamorphism into coal macerals; effects of environment; structure of coal macerals. *Mr. Given*

512. (Mat.Sc. 512) Principles of Crystal Chemistry (2-4) Relation of structure to ionic size and nature; influence of pressure and temperature on structure; chemical-structural defects, crystalline solutions, phase-transitions. *Mr. Roy*

513. Phase Equilibria in Mineral Systems at High Temperatures (2-4) Interpretation of phase diagrams with emphasis on high-temperature oxide systems at atmospheric pressure; measurement of p-t-x, determination of equilibrium diagrams. *Mr. Muan*

514. Element Distribution in the Earth (3) Principles and data from studies of phase equilibria, petrology, and crystal structure as related to distribution of elements in minerals, rocks, and the earth. *Mr. Wickman*

517. Age Determinations (1-2) Geochemistry of radioactive elements and their daughters; age determination techniques and observations. *Mr. Deines*

518. Stable Isotope Geochemistry (3) Theory of isotope fractionation mechanisms; its application to a wide range of problems in the earth and planetary sciences. *Mr. Deines*

520. P-T-X Phase Equilibria (3) Phase equilibrium in mineral systems with pressure as a variable. *Mr. Boettcher*

522. Geochemistry of Aqueous Systems (2-3) Ionic and molecular equilibria related to stabilities and solubilities of minerals: Eh-pH, Po_2-pH relations applied to ground water, sea water, hydrothermal fluids. Prerequisites: Chem. 451-452, Min. 483, 484. *Messrs. Barnes and Schmalz*

523. Water-Resource Geochemistry (2-4) Topics and problems concerning the chemical quality of surface waters and ground waters related to hydrogeologic and cultural controls. *Mr. Langmuir*

524. (Mat.Sc. 524) Vibrational Spectra of Materials and Minerals (2) Infrared and Raman spectroscopy of solid materials with applications to crystal chemistry, materials characterization and glass research. Prerequisites: Phys. 412, 471. *Mr. White*

525. Electronic Properties of Minerals (2) Application of spectroscopy to mineralogy, Crystal field, EPR, NMR, Mossbauer spectra. Application to order-disorder, element distribution, mineral stability. Prerequisites: Phys. 412, 471. *Mr. White*

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in geochemical studies are listed under Mineralogy.*

GEOGRAPHY (GEOG)

Wilbur Zelinsky, *Head of the Department*
442 Deike Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Deasy, Gould, Lewis, Miller, Rodgers, Simkins, Wernstedt, Williams, and Zelinsky.
Graduate Faculty: Associate Members Abler, Downs, and Knight.

The student may concentrate in subjects that call upon the special skills and interests of the staff. At the present time these include: geographic theory; methods of geographic analysis; the cultural geography of Anglo-America; population problems and the human use of the environment; microspatial behavior of individual actors in space; macrospatial analysis in regional and urban development; and regional development problems in Africa, Latin America, Southeast

Asia, and Southern Europe. All students receive training in cartographic, statistical, and bibliographic techniques.

Students wishing to specialize in the field of population may also qualify for admission to the Population Issues Studies Program. This program is a course of study focusing on the social, economic, and geographical policy-related issues resulting from the dynamics of population trends, especially in developed nations. In addition to departmental admission requirements, the Population Issues Studies Program committee evaluates the student's interest and aptitude for the training program, which consists of a minimum of 21 credits of interdisciplinary course work in population.

The student has the option for the M.S. degree to complete a thesis or two papers. The master's program is broadly based, designed to provide a beginning graduate student with basic training in systematic fields as well as in geographic theory and research techniques. This basic training underlies more specialized study at the doctoral level where a candidate selects two fields of concentration. A student may elect to specialize in the geography of a region only if faculty members have research experience in that region. The communication and foreign language requirement for the Ph.D. degree may be satisfied by either a reading competence in a modern foreign language with faculty approval or comparable facility in mathematics, statistics, or computer science.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

GEOGRAPHY (GEOG)

401. Historical Geography of North America (3) *Mr. Lewis or Mr. Zelinsky*
402. Cultural and Anthro-Geography (3) *Mr. Zelinsky*
405. Geography of Population (3) *Mr. Zelinsky or Mr. Simkins*
406. Human Use of Environment (3) *Mr. Knight*
407. Geography of Settlement (3) *Mr. Williams*
410. Cartography — Map Design and Construction (3) *Mr. Deasy*
412. The Geography of the Future (3) *Mr. Abler*
413. Behavioral Approaches to Geography (3) *Mr. Downs*
420. Urban Geography (3) *Mr. Caruso*
427. Geography of the Soviet Union (3) *Mr. Rodgers*
428. Geography of Eastern Europe (3)
430. Agricultural Geography (3) *Mr. Knight*
433. Regional Climatology (3) *Mr. Wernstedt*
434. Regional Physiography (3) *Mr. Lewis*
440. Geography of Middle America (3) *Mr. Simkins*
441. Geography of South America (3) *Mr. Simkins*
442. Regional Systems in Europe (3) *Mr. Miller*
443. Geography of the Orient (3) *Mr. Wernstedt*
444. Geography of Africa (3) *Mr. Knight*
445. Geography of Southern Asia (3) *Mr. Wernstedt*
450. Development of Geographic Thought (3) *Mr. Abler*
451. Map Interpretation (3) *Mr. Lewis*
452. Interpretation of Aerial Photographs (3) *Mr. Deasy*
454. Spatial Analysis I (3) *Mr. Gould, Mr. Strack, or Mr. Williams*
455. Spatial Analysis II (3) *Mr. Gould, Mr. Strack, or Mr. Williams*
457. Geographic Data Systems (4) *Mr. Williams*
460. Political Geography (3) *Mr. Lewis or Mr. Williams*
470. Industrial Location and Development (3) *Mr. Rodgers*
475. Geography of Communications Systems (3) *Mr. Abler*
480. Manufactural Systems Analysis (3) *Mr. Miller*
489. Problems in Geography (3) *Staff*
497. Directed Readings (1-9) *Staff*

500. Introduction to Geographic Research (3)

501. Geographic Bibliography (1) An introduction to the techniques of bibliographic search and the writing of research papers in geography. Prerequisite: Geog. 500.

502. Regional Theory (3) Taxonomic methods of uniform — functional regionalization; canonical linkages; intraregional relationships; Wilson models of macrocononical ensembles.

503. Advanced Regional Geography (3-12) Intensive study at an advanced level of selected regions or sections of the continents. Prerequisite: 12 credits in geography.

504. Physical Geography Seminar (3-12) The examination of current problems and theories in physical geography through critical discussion of the literature and student research.

505. Economic Geography Seminar (3-12) The examination of current problems and theories in economic geography through critical discussion of the literature and original student research.

506. Political Geography Seminar (3-6) The exploration of current problems and theory in political geography through critical discussion of the literature and original student research. Prerequisite: Geog. 460.

508. Cultural Geography Seminar (3-6) The exploration of current problems and theory in cultural geography through critical discussion of the literature and original student research.

509. Population Geography Seminar (3) Selected problems in population geography with emphasis on analysis and presentation of data. Prerequisite: Geog. 405.

517. Geographic Modeling (1) Spatial modeling, mapping and transformations of elementary geographic problems.

520. Metropolitan Analysis (3) Land use models, urban factorial ecology; intraurban movements; urban renewal, ghetto structure, residential change; commercial structure, blight. Prerequisite: Geog. 420 or 456.

567. Applied Quantitative Methods (3) Simulation, topological, queuing, programming, factor analytic, discriminant, and game theoretic models applied to geographic problems of spatial diffusion and interaction. Prerequisite: Geog. 456.

GEOLOGY (GEOL)

Robert F. Schmalz, *In Charge of Graduate Programs in Geology*
303 Deike Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Cuffey, Gold, Guber, Parizek, Ridge, Schmalz, Scholten, Spackman, Traverse, Voight, Weber, Williams, and Wright.

Programs are offered in stratigraphy, paleontology, sedimentation, paleobotany, palynology, regional and structural geology, geomorphology, ground water geology, engineering geology, marine geology and chemical oceanography, coal geology, coal petrology, and geology of metallic and nonmetallic deposits.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages or by comprehensive knowledge of one. The student has the option of a thesis or a paper for the M.S. degree.

For admission 25 credits in chemistry, physics, mathematics, and biological sciences, and at least 18 in geology and mineralogy are required. Students who have taken somewhat less than the indicated minimum in these subjects may be admitted but must make up their deficiencies concurrently with their graduate studies.

Students may be accepted with a previous degree in geophysics, physics, mathematics, engineering, earth sciences, or a closely allied field. Students whose grade-point average in courses

pertinent to geology is below 3.00 will be considered for admission when there are strong indications that this average can be maintained at the graduate level. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

GEOLOGY (GEOL)

400. Surface Geological Processes for Teachers (3) *Mr. Weber*
401. Earth History for Teachers (3) *Mr. Cuffey*
402. Field Methods for Teachers (3) *Mr. Guber*
410. Structural Geology (3) *Mr. Gold*
420. (Biol. 420) Paleobotany (3) *Mr. Spackman*
421. Introduction to Coal Petrology (3) *Mr. Spackman*
423. (Biol. 423) Introductory Palynology (3) *Mr. Traverse*
427. (Biol. 427) Evolution (3) *Mr. Cuffey*
430. Paleontology (3) *Mr. Guber*
435. Paleoecology (3) *Mr. Cuffey*
440. Marine Geology (3) *Mr. Schmalz*
451. Economic Geology (3)
452. Introduction to Hydrogeology (3) *Messrs. Langmuir and Parizek*
453. Mechanics of Geological Materials (3) *Mr. Voight*
461. Geology of North America (3) *Mr. Wright*
462. Principles of Geomorphology (3-6)
470. Introduction to Field Geology (3) *Mr. Wright*
472. Field Geology (5) *Mr. Gold*
481. Geology of Oil and Gas (3) *Mr. Scholten*
490. Stratigraphy (3) *Mr. Williams*

502. (Gchem. 502) Carbonates in the Marine Environment (3) Ancient carbonate rocks and recent carbonate sediments, with emphasis on modern field and laboratory methods and a multidisciplinary approach. *Mr. Weber*

*503. Paleontology (3-9) Morphology of animal groups significant for their fossils; nature of species and faunal zones. Seminars may be arranged for studies of special fossil groups, microfossils, paleoecology. *Mr. Cuffey*

504. History and Foundations of Geology (2-4) Theoretical aspects of geology: spatio-temporal organization of matter, dynamic processes, sequential development; basic patterns and history of scientific thought. *Mr. Williams*

**506. Sediments of the World (2-6) Evolution of sediments from Archean to Recent; relationship of sedimentation to geotectonism; kratonic and geosynclinal sediments; cyclicity. Prerequisites: Min. 512, 514. *Messrs. Scholten and Williams*

507. Seminar in Geomorphology (3-6) Classic and current literature in geomorphology.

511. Ore Deposits: Principles (3-6) Geological and geochemical processes controlling ore deposition; genetic classification of ore deposits. Prerequisite: Geol. 451.

512. Ore Deposits: Types (1-6) Geologic history and field examination of selected ore bodies; forming media; causes, sequences, and loci of emplacement; wall rock alteration; secondary enrichment. Prerequisite: Geol. 511.

524. Coal Petrology (1-6) Microscopy, source materials, coalification, constitution, classification of peats, lignites, bituminous coal, anthracite. *Mr. Spackman*

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*Credits to be arranged, 3 to 6 per term.
**Credits to be arranged, 2-3 per term.

526. (Biol. 526) Problems in Palynology (1-6) Systematics; paleoecological palynology; Paleozoic palynology; Mesozoic and Cenozoic palynology; Pleistocene vegetational history. *Mr. Traverse*

540. Chemical Oceanography (3) Chemical reactions in sea water and at the sea floor related to sedimentation and diagenesis. *Mr. Schmalz*

545. Glacial Geology (3) Glaciers: their characteristics, causes, deposits, landforms, effects in periglacial regions. *Mr. Parizek*

546. Principles of Photogeology (3) Use of aerial photographs and mosaics in structural, geomorphic, and rock distribution studies and in compilation of maps. Prerequisites: Geol. 410, 462.

551. Dynamic Structural Geology and Geotectonics (3-6) Phenomena of fracturing, faulting, folding; stress and (finite) strain analysis, physical and analytical models; deformational environments; testogenesis and orogenesis. *Messrs. Scholten and Voight*

555. Advanced Structure and Petrofabrics (1-3) Macroscopic and mesoscopic recognition, measurement, and interpretation of small-scale rock structures and mineral orientation patterns in deformed rocks. *Mr. Gold*

571. Geology Field Trip (1 per year) Field study of regional geologic features with trips in successive years to differing geologic provinces.

581. Habitat of Oil (3) Geologic setting of petroleum as determined by basin tectonism, sedimentation, hydraulic and capillary forces, and reservoir textures. *Mr. Scholten*

Note: *Additional general courses in this field are listed under Geological Sciences.*

GEOPHYSICS (GPHYS)

Shelton S. Alexander, *In Charge of Graduate Programs in Geophysics*
204 Mineral Sciences Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Alexander, Bell, and Howell.
Graduate Faculty: Associate Members Graham, Greenfield, and Lavin.

Students may specialize in seismology, physical properties of rocks, geophysical surveying, geomagnetism, paleomagnetism, geoelectricity, gravity, wave propagation, time-series analysis, space applications of geophysics, tectonics, earth physics, and planetary sciences.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages or by comprehensive knowledge of one. The nonthesis option is available for the M.S. degree.

For admission an applicant is generally expected to have had mathematics through differential equations; a standard introductory course each in physics, chemistry, and earth sciences; and at least 16 credits of intermediate-level work in any one or a combination of these subjects. Applicants who have taken somewhat less than the indicated minimum in these subjects may be admitted but must make up their deficiencies concurrently with their graduate studies.

Students may be accepted with a previous degree in geophysics, physics, mathematics, engineering, earth sciences, or a closely allied field. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Students with special backgrounds, abilities, and interests whose grade-point average in courses pertinent to geophysics is below 3.00 will be considered for admission when there are strong indications that a 3.00 average can be maintained at the graduate level.

GEOPHYSICS (GPHYS)

400. Physics of the Earth for Teachers (3) *Mr. Lavin*
406. Physics of the Earth (3) *Mr. Graham*

407. Well Logging (3) *Mr. Lavin*
408. Geophysical Surveying (3) *Mr. Lavin*
415. Gravity and Magnetic Surveying (3) *Mr. Lavin*
416. Electrical Surveying (3) *Mr. Greenfield*
417. Analysis of Time Series (3) *Mr. Lavin*
418. Potential Theory Applied to Earth Problems (3) *Mr. Alexander*

502. Seismic Instruments (3) Characteristics and design of seismometers and seismic recorders.

504. Communication Theory for Geophysicists (3) Basic theory of random processes leading to and including optimum filters; geophysical applications to gravity and seismic data analysis.

507. Seismology (3 per unit)
Unit A. Basic theory; seismic methods for inferring structure of planetary interiors; observational techniques; seismic event location, magnitude, and damage potential.
Unit B. Advanced wave propagation theory; mathematical representation of seismic sources; inversion theory; computational methods.

508. Tectonics (3) Seminar in the cause and nature of the principal deformations of the earth.

516. Introduction to Nuclear Processes in Geologic Settings (2) Natural radioactivity and its measurement, interpretation, and use in research and exploration.

521. Thermal State of the Earth (2) Methods and instrumentation of geothermal measurements; geothermal observations; development of the theory of the thermal state of the earth.

NOTE: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in geophysical studies are listed under Mineralogy.*

GERMAN (GER)

Stanley R. Townsend, *Head of the Department*
S-323 Burrowes Building

Degrees Conferred: Ph.D., M.A., M.Ed.

Graduate Faculty: Senior Members Ebbinghaus, Kopp, Preisner, Shelley, and Townsend.
Graduate Faculty: Associate Members Browning, de Levie, Keune, and Ziegler.

There is opportunity for major emphasis upon either literature or philology. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages.

Minimum qualifications for admission include 27 undergraduate credits in German beyond the intermediate level; provision is made, however, for admission with limited deficiencies. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Students may qualify for the M.A. and M.Ed. degrees either by writing a thesis — which is recommended if a student wishes to be considered for Ph.D. candidacy — or by submitting an essay to the department and taking additional 500-level German courses in lieu of 6 credits of thesis research.

GERMAN (GER)

401. Advanced Stylistics (3)
411. The Teaching of German (3)
430. History of the German Language (3)

443. (C.Lit. 443) Literary Relations of Germany with England and America (3-9)
454. Literature from the Age of Chivalry to the Thirty Years' War (3)
464. Literature from the Beginning of the Enlightenment Through Storm and Stress (3)
469. Goethe's Life and Works (3)
474. Classicism and Romanticism (3)
484. Literature from Realism to Expressionism (3)
495. Independent Study (1-9)

*1G. Elementary German for Graduate Students (3) Designed for students preparing to satisfy language requirements for advanced degrees.

*2G. Elementary German for Graduate Students (3) Continuation of Ger. 1G with opportunity for reading in special fields.

500. Bibliography and Research Techniques (3) Introduction to tools and methods of research, designed for students preparing for independent investigation of problems in German literature and language.

520. Introduction to Middle High German (3) Descriptive and historical grammar; readings in simple Middle High German texts.

521. Readings in Middle High German (3) Intensive reading in Middle High German literature, especially of the *Blütezeit.* Prerequisite: Ger. 520.

522. Old High German (3) Essentials of the grammar with special treatment of the High German sound shift and of ablaut and umlaut; reading of works written before 1100 A.D.

523. Gothic (3) Introduction to the historical and comparative Germanic grammar; emphasis on the Gothic language and texts. Suitable for advanced students in English.

525. Old Icelandic (3) Introduction to Old Icelandic grammar; readings in Old Icelandic prose. Suitable for advanced students in English.

531. Seminar in Medieval German Languages and Literatures (3-6)

541. Seminar in the Literature of the Reformation and Baroque (3-6)

551. Seminar in the Literature of the Enlightenment and the Age of Goethe and Schiller (3-6)

561. Seminar in Post-Idealistic Literature (3-6)

571. Seminar in Modern German Literature (3-6)

581. Seminar in Literary Genres (3-12) Special studies in the German lyric, drama, short story, and novel.

591. Seminar in German Literary Criticism (3)

595. Independent Study (1-9) Selected projects in the study of German literature and philology. Prerequisite: Ger. 500.

HIGHER EDUCATION (HI ED)

LARRY L. LESLIE, *In Charge of Graduate Programs in Higher Education*
319 Rackley Building

Degrees Conferred: D.Ed., M.Ed.

Graduate Faculty: Senior Members Anderson, Gillie, Ikenberry, Leslie, Lutz, Martorana, Sweitzer, and Willower.
Graduate Faculty: Associate Members Flexner, Godbey, Lindsay, Morrison, and Mortimer.

The graduate program in the higher education major has as its goal the preparation of individ-

*No graduate credit is given for this course.

uals who will pursue careers as administrators, faculty, or researchers in the nation's colleges and universities and in a variety of public and private agencies and associations. With emphasis on the systematic study of higher education, the program builds on the scholarly and scientific disciplines offered throughout the University and applies these studies to the professional functions and responsibilities which its graduates will assume.

With mounting awareness of the need for educational reforms and for improved teaching, other departments throughout the University encourage their graduate students to pursue a minor in higher education. The higher education faculty cooperates in this program — which is administered through the students' major departments — by offering a number of courses and seminars designed to promote understanding of post-secondary-school teaching.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be given priority for admission to the master's program; a grade-point average of 3.50 for master's work completed is preferred for admission to the doctoral program. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Some outstanding students may be admitted to the doctoral program with only the baccalaureate degree, but will earn the master's degree *en route.* For special requirements in the higher education major, write: Higher Education, The Pennsylvania State University, 319 Rackley Building, University Park, Pa. 16802.

HIGHER EDUCATION (HI ED)

545. HIGHER EDUCATION IN THE UNITED STATES (2-3) A basis for all courses in higher education. Current issues are analyzed and trends of the future anticipated.

546. COLLEGE TEACHING (2-3) Principles involved in teaching at the college level; effective use of teaching aids; criteria used in evaluation.

547. INTERNSHIP IN HIGHER EDUCATION (1-9) Supervised experience in administrative offices, in research, on instructional teams, and in college teaching.

548. CURRICULUMS IN HIGHER EDUCATION (2-3) Various types of curriculums and philosophies underlying them; ways in which curriculums are developed; elective versus required courses; evaluation of achievement.

549. COMMUNITY JUNIOR COLLEGE AND THE TECHNICAL INSTITUTE (2-3) Distinctive contributions to meeting the need for post-secondary education; development, functions, curriculum and instruction, government, administration and finance.

550. THE PROFESSIONS AND THE EDUCATION OF TEACHERS (3) The nature of a profession and dimensions of professional education in the United States are explored. Trends and issues examined.

552. ADMINISTRATION IN HIGHER EDUCATION (2-3) Philosophy of administration; principles of scientific management and their application in colleges and universities; case studies of administrative problems. Prerequisite: courses or experience in higher education.

554. THE HISTORY OF AMERICAN HIGHER EDUCATION (3) An examination of the development of American higher education against the background of influential social, political, economic, and intellectual issues.

555. SEMINAR IN HIGHER EDUCATION (1-6) Special topics in higher education.

556. COLLEGE STUDENTS (3) Characteristics of college students; changes during college years; educational challenges and responses. Prerequisites: Hi. Ed. 545, Psy. 426, I.F.S. 435 or permission of instructor.

589. PROBLEMS, PROJECTS, AND AREA STUDIES IN HIGHER EDUCATION (1-6) Independent work in the study of topics in higher education, or development of new curriculums, materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of the department head.

HISTORY (HIST)

KENT FORSTER, *Head of the Department*
601 Liberal Arts Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty: Senior Members Borza, Brown, Dahmus, Eggert, Forster, Frantz, Hassler, Maddox, McNall, Murray, Silverman, Sun, and Utechin.
Graduate Faculty: Associate Members Ameringer, Duiker, Enteen, Goldschmidt, Green, Knight, Linker, Meier, Spielvogel, and Stebbins.

Graduate work is offered in the following areas of history: ancient, medieval, Europe since 1500, Great Britain and the British Empire, Russia and Eastern Europe, the Middle East, the Far East, the United States, and Latin America. These areas are subdivided into chronological, national, and topical fields.

The candidate for the M.A. or M.Ed. degree selects one of the above areas for his master's examination. He must take some courses in an area in history other than his examination area and in a cognate field. (The cognate field for an M.Ed. candidate must be in education.) With the consent of his adviser, a master's candidate may substitute additional course work and a paper for a thesis.

The candidate for the doctor's degree must pass examinations in one of the above areas, in a thesis field within that same area, and in one field from a second area. He must also pass an examination in a single cognate field, or in a study area made up of a number of academic disciplines related to the subject of his thesis. The communication and foreign language requirement for the Ph.D. may be satisfied by a reading knowledge of two foreign languages or one language and work in quantitative techniques. The D.Ed. candidate has no foreign language requirement; however, he must minor in education.

The entering student should present evidence of undergraduate course work covering the history of Europe from ancient times to the present and the history of America from its discovery to the present. Students with a 3.00 junior-senior average and better than a 3.00 average in all undergraduate history courses and appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Each applicant must provide Graduate Record Examination scores and at least three letters of recommendation.

HISTORY (HIST)

400. SELECTED TOPICS IN HISTORY (3-6)
401. CLASSICAL CIVILIZATION (3) *Mr. Borza*
403. THE MIDDLE AGES FROM CONSTANTINE TO THE CRUSADES (3) *Mr. Dahmus*
404. THE MIDDLE AGES FROM THE CRUSADES TO THE RENAISSANCE (3) *Mr. Dahmus*
405. BYZANTINE CIVILIZATION (3)
408. INTELLECTUAL HISTORY OF THE MIDDLE AGES (3) *Mr. Dahmus*
410. THE RENAISSANCE (3) *Mr. Spielvogel*
411. THE REFORMATION (3) *Mr. Spielvogel*
413. THE AGE OF ABSOLUTISM (3) *Mr. Green*
414. THE FRENCH REVOLUTION AND THE NAPOLEONIC ERA (3) *Mr. Green*
417. NINETEENTH CENTURY EUROPE (3) *Mrs. Rosenblatt*
419. RECENT EUROPEAN HISTORY (3) *Mr. Forster*
422. HISTORY OF THE AMERICAN FRONTIER (3) *Mr. McNall*
425. HISTORY OF AMERICAN POLITICAL PARTIES (3)
426. THE DIPLOMATIC HISTORY OF THE UNITED STATES TO 1900 (3) *Mr. Maddox*
427. THE DIPLOMATIC HISTORY OF THE UNITED STATES SINCE 1900 (3) *Mr. Maddox*
428. AMERICAN MILITARY HISTORY (3) *Mr. Hassler*
430. COLONIAL AMERICA TO 1753 (3) *Mr. Frantz*
431. REVOLUTIONARY AMERICA, 1753-1783 (3) *Mr. Frantz*

432. The Formative Period of American History (3) *Mr. Brown*
433. The Middle Period of American History (3) *Mr. McNall*
434. The United States in Civil War and Reconstruction (3) *Mr. Hassler*
435. The Emergence of Modern America (3) *Mr. Eggert*
436. America Between the Wars (3) *Mr. Murray*
437. Recent American History (3) *Mr. Murray*
439. History of England in the Middle Ages (3) *Mr. Dahmus*
440. Britain Under the Tudors and Stuarts, 1485-1688 (3) *Mr. Linker*
441. Great Britain, 1688-1832 (3) *Mr. Linker*
442. History of Russia to 1700 (3) *Mr. Utechin*
443. Imperial Russia, 1700-1917 (3) *Mr. Utechin*
444. Eastern Europe in Modern Times (3) *Mr. Enteen*
447. Social and Economic History of Europe Since 1750 (3) *Mr. Silverman*
448. Intellectual and Cultural History of Modern Europe (3) *Mrs. Knight and Mr. Silverman*
449. Diplomatic History of Europe Since 1870 (3) *Mr. Forster*
452. Social and Cultural History of the United States Since 1783 (3) *Mr. Brown*
453. American Economic History in the Agricultural Era (3) *Mr. McNall*
454. American Economic History in the Industrial Era (3) *Mr. Eggert*
456. (L.S. 456) History of American Labor (3) *Mr. Eggert*
458. Constitutional History of the United States to 1877 (3) *Mr. Stebbins*
459. Constitutional History of the United States Since 1877 (3) *Mr. Stebbins*
460. Latin America and the United States (3) *Mr. Ameringer*
462. Mexico and the Caribbean Nations in the Twentieth Century (3) *Mr. Ameringer*
463. Spanish Conquest of the New World (3) *Mr. Garner*
464. Latin American Independence Movements (3) *Mr. Garner*
467. Alexander the Great and the Hellenistic World (3) *Mr. Borza*
468. The Roman Republic (3) *Mr. Borza*
469. The Pax Romana (3) *Mr. Harvey*
470. The Later Roman Empire (3) *Mr. Harvey*
471. Nineteenth Century China (3) *Mrs. Sun*
472. Twentieth Century China (3) *Mr. Duiker*
479. Modern Vietnam, Laos, and Cambodia (3) *Mr. Duiker*
480. History of Arabic Civilization, 600-1258 (3) *Mr. Goldschmidt*
481. The Ottoman Empire and Other Muslim States (3) *Mr. Goldschmidt*
482. The Contemporary Middle East (3) *Mr. Goldschmidt*
485. History of Central and East Africa (3) *Mr. Griffith*
486. History of West Africa (3) *Mr. Griffith*
491. History of the Soviet Union (3) *Mr. Enteen*
492. Great Britain Since 1832 (3) *Mr. Linker*
497. Germany Since 1640 (3) *Mr. Silverman*

501. Historical Method (3) *Mr. Meier*

502. Historiography (3) *Messrs. Borza and Meier*

503. Studies in Medieval English History (3-6) A seminar in the political, economic, and cultural history of England in the Middle Ages. *Mr. Dahmus*

504. Medieval Civilization (3-9) *Mr. Dahmus*

505. The Age of the Reformation (3-6) *Mr. Spielvogel*

507. Studies in European History, 1600-1750 (3-6) *Mrs. Knight and Mr. Green*

508. Studies in European History, 1750-1900 (3-6) *Mr. Silverman*

509. Studies in Twentieth Century Europe (3-6) *Messrs. Forster and Silverman*

512. Studies in Pennsylvania History (3-6) *Mr. Frantz*

520. Colonial and Revolutionary America (3-6) *Mr. Frantz*

533. The United States, 1783-1860 (3-6) *Mr. McNall*

534. The United States, 1860-1877 (3-6) *Mr. Hassler*

535. The United States, 1877-1919 (3-6) *Mr. Eggert*

536. The United States Since 1919 (3-6) *Mr. Murray*

538. Diplomatic History of the United States (3-6) *Mr. Maddox*

539. Economic History of the United States (3-6) *Messrs. McNall and Eggert*

540. Studies in British History (3-6) *Mr. Linker*

544. Seminar in Eastern European History (3-6) *Messrs. Utechin and Enteen*

545. Studies in Russian and Soviet History (3-6) *Messrs. Utechin and Enteen*

552. Cultural History of the United States (3-6) *Mr. Brown*

559. Studies in Constitutional History (3-9) A graduate seminar examining constitutional developments in their historical context through readings, class discussions and research papers. *Mr. Stebbins*

562. Seminar in Latin-American History (3-6) *Mr. Ameringer*

563. Studies in the History of the Caribbean Area (3) Prerequisites: Hist. 22, 23. *Mr. Ameringer*

568. Studies in Greek History (3-6) *Mr. Borza*

569. Studies in Roman History (3-6) *Mr. Borza*

571. Studies in Asian History (3-9) *Mrs. Sun*

581. Studies in Middle Eastern History (3-6) *Mr. Goldschmidt*

HOME ECONOMICS EDUCATION (HE ED)

MARJORIE EAST, *Head of the Department*
212 Rackley Building

Degrees Conferred: D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members East, Ray, and Shear.

Research and graduate courses may be chosen to give emphasis to special areas of interest in home economics education, such as curriculum development; evaluation; teaching at the elementary, secondary, adult, or higher education levels; supervision; administration in colleges; or research.

Students who have majored as undergraduates in some aspect of home economics and who have achieved a grade-point average of at least 2.50 in their junior and senior years will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. Students wishing to be admitted to the doctoral programs must have completed a master's degree and will be admitted subject to limitations of departmental facilities. Exceptions will be made for students with special backgrounds, abilities, and interests.

HOME ECONOMICS EDUCATION (HE ED)

400v. Special Problems in Home Economics Education (1-3)
406v. Audio-Visual Methods for Home Economics (1-4)
410v. Supervision of Student Teachers (1-3)
427v. Teaching Home Economics (3)
443v. Adult Education in Home Economics (3)
463v. Senior Seminar (2)
466v. Student Teaching (9)
477v. Curriculum Development for Home Economics in Secondary Schools (3)
478v. Appraising Student Progress in Home Economics (3)

479v. READINGS IN HOME ECONOMICS EDUCATION (1-4)
480v. PROBLEMS IN TEACHING HOME ECONOMICS (3-6)
481v. EMPLOYMENT PREPARATION PROGRAMS IN VOCATIONAL HOME ECONOMICS (3)

502, 502v. HOME ECONOMICS INSTRUCTION AT THE COLLEGE LEVEL (3) Teaching techniques suitable for college instruction in home economics; for prospective home economics college teachers.

503, 503v. HOME ECONOMICS TEACHER EDUCATION (3) Organization of college programs of teacher education; use of resources; records; field services; recruitment and selection of personnel. Prerequisite: two years' experience in teaching home economics.

504, 504v. EDUCATIONAL ISSUES AND HOME ECONOMICS (3) Contemporary issues in education and their relationship to the teaching of home economics. Prerequisite: teaching experience.

510, 510v. EDUCATIONAL LEADERSHIP IN HOME ECONOMICS (2-6) Principles of educational leadership for home economics preparing for administration; supervision of city and state programs; supervision of student teachers. Prerequisites: graduation from a four-year teacher education major and two years' teaching experience in home economics.

511, 511v. INTERNSHIP IN HOME ECONOMICS SUPERVISION AND ADMINISTRATION (2-8) Opportunity to understudy an educational leader in student teacher supervision, state supervision, department or college administration, or regional consultation. Prerequisite: H.E.Ed. 510.

518, 518v. EVALUATION OF HOME ECONOMICS PROGRAMS (3) Methods of evaluating progress toward goals in home economics education and use of findings in program planning and revision.

521, 521v. HOME ECONOMICS EDUCATION SEMINAR (2-3) Selected topics and recent developments in home economics education. Conferences and guidance relative to individual research problems.

530, 530v. PROBLEMS IN HOME ECONOMICS EDUCATION (1-6 per term) Individual investigation of problems related to the teaching, supervision, or administration of home economics education.

HORTICULTURE (HORT)

ROGER W. HELPER, *Acting Head of the Department*
103 Tyson Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members Bergman, Grun, Hitz, Larson, McArdle, Ritter, Shannon, Smith, Stinson, and Tukey.
Graduate Faculty: Associate Members Beelman, Craig, Haramaki, Hatch, Hepler, Kuhn, Martsolf, Mastalerz, Pfahl, and White.

Students may specialize in climatology, propagation, several phases of production, fruit and vegetable processing, plant genetics and breeding, plant nutrition, and various environmental and post-harvest physiological studies of horticultural crop species.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by one of three options: (1) comprehensive competence in one language, (2) reading examination or two-course sequence in two languages, or (3) reading examination or two-course sequence in one language plus 6 credits in other communications skills.

Students wishing additional credits in floriculture, olericulture, ornamental horticulture, plant breeding and genetics, plant nutrition, climatology, or pomology should register for Hort. 501.

Prerequisites for admission vary according to the area of specialization; but basic courses in physical sciences, mathematics, biological sciences, communication skills, and social sciences

and humanities are required. Students who lack prerequisite courses may be admitted but are required to fulfill deficiencies without degree credit.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students.

HORTICULTURE (HORT)

401. Plant Propagation (3) *Mr. Haramaki*
402. Plant Nutrition (3) *Mr. Bergman*
403. Horticultural Plants and Their Environment (3) *Mr. Mastalerz*
404. Advanced Horticultural Crop Science (3-12)
405. Senior Seminar in Horticulture (1-2)
407. Plant Breeding (3) *Mr. Hepler*
412. Post-Harvest Physiology (3) *Mr. Ritter*
444. Advanced Plant Breeding (3-6) *Mr. Craig*
447. Problems in Horticulture (1-9)
451. Flower Store Management (4) *Mr. Pfahl*

501. Experimental Problems in Horticultural Science (1-12) Investigation of problems in floriculture, olericulture, ornamental horticulture, plant breeding, nutrition, or pomology.

506. Nutrition of Horticultural Crops (2-4) Principles, applications, and interpretations of diagnostic methods for determining fertilizer requirements of horticultural crops. *Mr. Smith*

507. Physiological Genetics and Plant Breeding (3) Physiological genetics in improving the biological efficiency and utilization of plants. Prerequisites: Bioch. 42 or Biol. 442, 6 credits in genetics and/or plant breeding.

512. Principles of Fruit and Vegetable Storage (2-4) Principles involved in the maturation, storage, and senescence of fruits and vegetables, and their application. *Mr. Ritter*

514. Propagation and Improvement of Horticulture Plants (1-6) Biological factors affecting sexual and asexual propagation of plants; techniques in plant improvement; maintenance of propagation material.

517. Horticultural Seminar (1 per term) Review of current research publications in horticulture. Each student presents one or more reviews of assigned topics.

520. Genetics and Breeding Seminar (1 per term) Review of research and literature in genetics and breeding of horticultural crops.

524. Experimental Procedures in Horticultural Research (3) *Mr. Craig*

528. Problems in Fruit and Vegetable Processing (2-12) *Mr. McArdle*

HUMAN DEVELOPMENT AND FAMILY STUDIES (HD FS)

JOSEPH H. BRITTON, *In Charge of Graduate Program in Human Development and Family Studies*
S-105E Human Development Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Baltes, Bortner, Britton, Danish, de Lissovoy, Ford, Gottlieb, B. Guerney, Gunter, Harms, Harris, Hultsch, Knoll, Looft, Nesselroade, Peters, Stein, W. Smith, Taylor, Urban, and Walcher.
Graduate Faculty: Associate Members Cohen, D'Augelli, Deutsch, Friedrick, Gage, Goldberg, L. Guerney, Hickey, Huston, Kirchner, Kurtz, Neisworth, Peterman, Ridley, Seward, R. Smith, Vondracek, and Willis.

This interdisciplinary program focuses on the developmental study of individuals, small groups, and families for the purposes of expanding basic knowledge and professional application. The perspective encompasses the individual life span, from infancy and childhood through later maturity and old age, as well as the full cycle of the family. For both individual and family, the perspective includes variations in functioning patterns and the use of resources; the impact of diverse social, economic, and cultural contexts upon behavior; and conditions and professional procedures which foster positive and constructive development. Emphasis is upon the integration of knowledge from various fields for understanding and developing skills for careers in research and scholarship, teaching, program planning and evaluation, and other professional services. The faculty includes persons primarily in the behavioral and social sciences.

The student's program is expected to include work assuring both breadth in the major field and depth within one of three program areas: family development, human development intervention, or individual development. Further specialization is possible in early childhood education, interpersonal relations, family economics and management, and educational gerontology.

Infant and preschool laboratories are operated as part of the teaching and research program. Each unit has observational facilities and rooms for study of individual and group behavior of children and adults. The Individual and Family Consultation Center provides facilities for the development and evaluation of educational programs for remediation of individual and family problems by professional and paraprofessional persons. The institute for the Study of Human Development, the Center for Human Services Development, the Center for Youth Study and Social Policy, the Pennsylvania Field Research Laboratory, and a simulation laboratory provide opportunities for participation in research and evaluation projects. Additional resources are available in other parts of the University.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign languages. A minor or general studies group outside the major is required of all doctoral students.

Entering students should have at least 6 credits in the biological and physical sciences; 12 in the social sciences and, depending upon proposed area of emphasis, basic courses in sociology, psychology, and economics; and 6 in developmental and family studies. Students not meeting these requirements may be admitted with limited deficiencies to be made up concurrently with their graduate work.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission, which, with rare exception, will be for fall term only. Early application is required; the best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

INDIVIDUAL AND FAMILY STUDIES (I F S)

410. COMMUNITIES AND FAMILIES (3)
411. THE HELPING RELATIONSHIP (3)
413. DYSFUNCTIONS IN THE DEVELOPMENTAL PROCESS (3)
414. RESOLVING INDIVIDUAL AND FAMILY PROBLEMS (3)
415. CHILD DEVELOPMENT AND FAMILY RELATIONSHIPS FOR SECONDARY SCHOOLS (3)

416. (C.S. 416) Consumer Role of Family (3)
418. Family Relationships (3)
419. Problems of Family Financial Management (3)
420. Problems in the Analysis of Individual Development (3-9)
424. Economic Conditions in Relation to the Family (3)
427. Conceptions in Development (3)
428. Infant Development (3)
429. Advanced Child Development (3)
430. Practicum in Preschool Groups (1-6)
432. Developmental Problems of Normal Children (3)
435. Developmental Transition to Adulthood (3)
439. Family Resource Management (2)
441. Organization Planning for Preschool Programs (3)
442. Home Management Experience (3)
445. (Psy. 445) Development Throughout Adulthood (3)
477. Analysis of Family Problems (2-9)
481. Developmental Programming for Preschool Children (3)

500. Nonthesis Research (1-9)

501. Seminar: Issues in the Study of Individual and Family Development (1-3) Reading, reports, and discussion of conceptual frameworks for multidisciplinary and developmental study of individuals and families.

504. Practicum in Program Development for Preschool Children (2-6) Investigation, analysis, and report on the design, development, and evaluation of a selected program for preschool children. Prerequisites: 6 credits of individual development and I.F.S. 430, 441.

506. Projects in Design and Evaluation of Programs for Preschool Children (2-4) Individual projects in the design, implementation, and evaluation of different teaching approaches with varying groups of children. Prerequisites: I.F.S. 504 and 3 credits in research methods.

508. Parental Education (1-6) Implementing educational and preventive programs for parents; discussion and evaluation of theory and techniques.

511. Modifying Conjugal Life (1-9) Conceptual foundations, research procedures, and practicum experience in teaching effective communication and problem-solving skills in the marriage relationship. Prerequisites: 6 credits in individual development or psychology and 3 credits in statistics.

512. Filial Relationship Modification (1-9) Theory, research, and practicum in teaching parents to resolve developmental problems in their own children. Prerequisites: 6 credits in individual development or psychology and 3 credits in statistics.

513. Group Procedures in Individual Development (1-6) Theory, research, and practicum experience in the use of group methods for promoting individual development in different age groups. Prerequisites: I.F.S. 411 and research methods or statistics.

515. Teaching Individual Development and Family Studies (1-6) Objectives, techniques, materials, and evaluation in teaching at the secondary and college level, and in adult and public education programs.

520. Seminar in Prenatal and Infant Development (1-6) Prenatal and infant development, with emphasis on multiple determinants of early development and their relationship to later behavior. Prerequisites: 6 graduate credits in individual development, psychology, or biological science and 3 credits in statistics.

522. Seminar in Dysfunctional Processes in Individual Development (1-6) Multiple processes involved in dysfunctional development in the individual across the life-span. Prerequisite: I.F.S. 413.

524. Theoretic Analysis of Family Economic and Managerial Behavior (3) Conceptual approaches and major contributions to the study of the organizational, managerial, and economic functions of the family. Prerequisite: I.F.S. 418 or 424 or 477.

525. THEORIES OF FAMILY RELATIONSHIPS (3) Assessment of the utility of major theories for empirical analysis of interpersonal interactions among family members. Prerequisite: I.F.S. 418.

528. TEACHING HOME MANAGEMENT (2-3) Development and evaluation of teaching objectives and methods in college and adult-level home management courses.

529. (Psy. 529) SEMINAR IN CHILD DEVELOPMENT (1-6) Readings and reports on recent findings in child development. Prerequisites: 6 graduate credits in child development, child psychology, or educational psychology, plus 3 in statistics.

530. INDEPENDENT STUDY IN INDIVIDUAL AND FAMILY STUDIES (1-9) Problems involving individual study. Prerequisite: instructor's approval of proposed study.

532. FIELD PROJECTS IN INDIVIDUAL AND FAMILY STUDIES (1-9) Supervised research or internship in human services program. Prerequisite: instructor's approval of proposed project.

536. (Psy. 536) RESEARCH METHODS IN DEVELOPMENTAL PROCESSES (3) Methodological issues in research on varying stages of development across the individual life-span. Prerequisites: 6 credits in individual development or psychology and a course in statistics.

539. SEMINAR IN ADOLESCENT DEVELOPMENT (1-6) Cultural, psychological, and biological aspects of the developmental transition to adulthood. Prerequisites: 6 credits in individual development or psychology and 3 credits in sociology and statistics.

543. MODIFICATION OF FAMILY MANAGERIAL PRACTICES (1-3) Conceptual issues, research, and practicum experience in assisting families in the solution of financial and managerial problems.

544. SEMINAR IN DYSFUNCTIONAL PATTERNS IN FAMILY ORGANIZATION (1-6) Processes of familial dysfunction and disorganization and their explanation in economic, social-psychological, and managerial terms. Prerequisite: I.F.S. 418 or 424 or Soc. 430.

545. FAMILIES AND SOCIOECONOMIC SYSTEMS (1-6) Functional interrelationships between families and social and economic systems. Prerequisites: I.F.S. 418, 424.

546. SEMINAR IN FAMILY RELATIONSHIPS (1-9) Interpersonal interaction within family systems throughout the life cycle. Prerequisite: I.F.S. 418.

549. (Psy. 549) DEVELOPMENTAL THEORY (3) Conceptual frameworks and major contributions to the study of individual development across the life-span. Prerequisite: 6 credits at the 400 level in individual development or psychology.

550. SEMINAR IN FAMILY ECONOMICS AND MANAGEMENT (1-6) Recent developments in the study of family economic and managerial practices.

579. SEMINAR IN ADULT DEVELOPMENT AND AGING (1-9) A seminar dealing with specific topics concerning adult development and aging. Prerequisites: I.F.S. 445 and statistics.

HUMANITIES (HUMAN)

NANCY M. TISCHLER, *Chairman, Humanities Program*
Capitol Campus, Middletown, Pa. 17057

Degree Conferred: M.A.

Graduate Faculty: Senior Members Chen, Dordevic, Lear, Richman, Tischler, and G. Wolf.
Graduate Faculty: Associate Members Anderson, Eisenstein, Knight, McAree, Patterson, and M. Wolf.

This program aims at developing skills in the interdisciplinary study of art, music, literature, and philosophy. Entering students are expected to have considerable background in at least two of these areas. A committee will meet with each student to determine his individual needs and arrange a program designed to help him develop essential skills for the analysis of music, art, literature, and philosophy; for the classification of works into genres, periods, and schools; for the evaluation of works by applications of appropriate criteria; for the definition of individual, school, and period styles; and for the perception of relationships between various styles, media,

periods, and cultures. For students who plan to teach in a junior college, there is also provision for an internship option.

A series of seven 500-level courses are designed to help a student develop a number of these skills. In addition, his adviser may suggest he enroll in certain 400-level courses or in independent studies with qualified faculty.

Each student is required to submit a master's production (a critical paper or a creative work accompanied by a paper) which will demonstrate his competence in humanistic study. A committee will judge this production.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

This program is available only at the Capitol Campus.

HUMANITIES (HUMAN)

500. Research Methods (3) Study of the methods and materials of scholarship, compilation of bibliographies, writing of scholarly papers, and proper documentation.

501. Presuppositions in the Humanities (3) Assumptions about knowledge, reality, and value which influence the humanist in his choice of ideas, methods, and modes.

502. Perennial Issues in the Humanities (3) Recurrent issues viewed in terms of their significance to the artist, historian, and the philosopher.

503. Interrelations in the Humanities (3) An interdisciplinary study of the interdependence of aesthetic values in various art forms as they exist in cultural settings.

520. Studies in Style (3) Study of prominent stylistic patterns, evaluating the essence of a style, and the varied responses of the artist and philosopher within a pattern.

525. Studies in Aesthetics (3) Study of certain techniques in the arts that presuppose certain aesthetic concepts and certain ideas that demand parallel form.

580. Master's Production (1-6) An original scholarly master's paper or creative production initiated by the student, supervised by an appropriate professor, and judged by a committee.

EDUCATION (ED)

520. Seminar in Junior College Teaching (3) The history of the two-year college, responsibilities of the teacher in the college organization, and methods of teaching.

550. Internship in Junior College (3) Teaching humanities courses in a two-year college under a master teacher, who will direct, criticize, and evaluate the intern.

INDUSTRIAL ARTS EDUCATION (IA ED)

Donald R. Chipley, *In Charge of Graduate Programs in Industrial Arts Education*
159 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Associate Members Koble and Shemick.

Emphasis may be placed on research, curriculum development, or teacher education. The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign languages.

Graduation from an approved major in industrial arts and at least 18 credits in education and related psychology are required for admission. Students with a 2.75 junior-senior average, appropriate course background, and one year of teaching experience will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are

available for new students. Exceptions to the minimum 2.75 grade-point average may be made for students with special backgrounds, abilities, and interests.

A candidate for an advanced degree in this major should check with his program adviser for courses whcih are applicable to a specific degree from those listed on pages 81-82 in this bulletin.

INDUSTRIAL ENGINEERING (I E)

BENJAMIN W. NIEBEL, *Head of the Department*
207 Hammond Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Draper, Ham, Lancaster, Niebel, and Rosenshine.
Graduate Faculty; Associate Members Addison, Freark, Guild, Keith, Raphael, Thuering, and Zindler.

Graduate study and research are conducted in operations research-management science, production engineering, process design, systems engineering, and human engineering.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by an intermediate knowledge of one foreign language.

Graduates in industrial engineering, other engineering curriculums, and mathematics who present a 2.50 junior-senior average will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

The Master of Engineering degree program is also offered at the King of Prussia Graduate Center.

INDUSTRIAL ENGINEERING (I E)

400. ENGINEERING FOR PRODUCTION (3)
402. ENGINEERING ECONOMY (3)
403. ENGINEERING ECONOMY AND STATISTICS (3)
404. MANAGEMENT SCIENCE (3)
405. LINEAR PROGRAMMING (3)
406. DESIGN OF PRODUCTION AND DISTRIBUTION SYSTEMS (3)
407. QUANTITATIVE METHODS FOR OPERATIONS RESEARCH (3)
408. HUMAN FACTORS ENGINEERING (3)
422a,b,c,d,e,f. INDUSTRIAL ENGINEERING PROBLEMS (2-12)
423. QUALITY CONTROL (3)
424. JOB EVALUATION (3)
425. INTRODUCTION TO OPERATIONS RESEARCH (3)
426. INDUSTRIAL AUTOMATION (3)
427. SOLIDIFICATION OF CASTINGS (3)
428. FOUNDRY ENGINEERING (3)
432. INTRODUCTION TO RELIABILITY ENGINEERING (1-3)
438. METAL CUTTING PRINCIPLES AND PRACTICE (3)

501. MANUFACTURING METHODS (2-8) Special projects including investigation; experimentation, design, and research of one or more special types of manufacture.

502. MANAGEMENT METHODS (3-6) Scientific management, including management controls and mathematical programming; research on special problems.

503. INDUSTRIAL RELATIONS (1-6) Study of human problems related to labor unions, hierarchy, specialization; analysis of organizational structure, policies, decision criteria, and communication systems.

504. Advanced Quantitative Methods in Industrial Engineering (3) Study of statistical and analytical decision models important in industrial engineering with emphasis on inference and testing of hypotheses. Prerequisites: Math. 62 and 3 credits in statistics.

506. Advanced Work Design and Measurement (3-9) Methods of research in motion and time study; critical analysis of current literature.

507. Operations Research: Scheduling Models (3) Scheduling models with simultaneous job arrival and probabilistic job arrival, network scheduling and scheduling simulation techniques. Prerequisites: I.E. 323, 402.

508. Operations Research: Inventory Models (3) A study of inventory theory, deterministic models, probabilistic models, multiproduct models in both the single and multiperiod modes. Prerequisite: I.E. 425.

509. Operations Research: Waiting Line Models (3) Waiting line models including models with infinite queues, finite queues, single and multiple servers under various priorities and disciplines. Prerequisite: I.E. 425.

510. Mathematical Programming (3) Study of advanced topics in linear programming including duality, decomposition, sensitivity analysis, parametric programming, and selected topics in mathematical programming. Prerequisite: I.E. 405.

511. Experimental Design in Engineering (3) Statistical design and analysis of experiments in engineering; experimental models and experimental designs using the analysis of variance. Prerequisites: Math. 63 and 3 credits in statistics.

512. Graph Theory and Networks in Management Science (3) Prerequisite: I.E. 405.

513. Real Time Data Processing for Engineering Systems (3) Random access computers and communication components for real time systems; engineering systems simulation on digital computers. Prerequisite: Cmp.Sc. 102 or 410.

515. Complex Linear Flow Models (3) Application of complex linear flow models in engineering and management science, including static and dynamic system simulations. Prerequisite: I.E. 512.

516. Applied Stochastic Processes I (3) Prerequisites: I.E. 323, Stat. 418.

517. Applied Stochastic Processes II (3) Prerequisite: I.E. 516.

518. Plastic Deformation Processes (3) Study of the principles, theories, technology, design, and application of plastic deformation processes to shape metals. Prerequisite: undergraduate engineering degree.

528. Metal Cutting Theory (3) Study of the theory of metal cutting, contemporary and future problems of metal removal processes; critical analysis of current literature. Prerequisite: I.E. 438.

538. Experimental Investigations in Materials Processing (3) Experimental investigation on selected subjects in processing involving instrumentation, methods, and analysis. Prerequisite: I.E. 528.

JOURNALISM (JOURN)

Robert M. Pockrass, *In Charge of Graduate Programs in Journalism*
220 Carnegie Building

Degree Conferred: M.A.

Graduate Faculty: Senior Members Barnes and Harrison.
Graduate Faculty: Associate Members Dulaney, Froke, Goodwin, Norris, Pockrass, and Smith.

The program is flexible so as to meet the needs of students with various undergraduate or professional backgrounds. Candidates may select a 30-credit thesis program or a 36-credit nonthesis program. Generally, the thesis program is for those with an undergraduate major or

professional experience in journalism or communications, or for those who plan to pursue a doctoral degree. Its purpose is to provide an understanding of the structure and functions of communications in modern societies, and a strong minor in an appropriate field is normally required. The nonthesis program is usually selected by candidates with undergraduate majors in the humanities or social sciences and who now wish intensive professional training for a journalistic career. All candidates must take at least one course dealing with research in communications problems. Other requirements are tailored to the individual's background, interests, and goals.

Students who achieved at least a 2.50 junior-senior average in an appropriate undergraduate field of study will be considered for admission. Those with lower averages will be considered if their achievements since graduation recommend them. Applicants must submit an autobiographical statement of about 1,000 words indicating career objectives and type of program preferred.

JOURNALISM (JOURN)

401. Critics and Ethics of the Mass Media (3) *Mr. Harrison*
404. Mass Media in History (3)
405. International Mass Communications (3)
406. Evaluation and Uses of Mass Communications Research (3) *Mr. Colldeweih*
419. (Spch. 419) Comparative Broadcasting Systems (3)
421. Editorial Interpretation (3) *Mr. Harrison*
422. Cultural Aspects of the Mass Media (3) *Mr. Pockrass*
424. Public Affairs Reporting (3)
430. Journalism in the Schools (3-6)
436. (Soc. 436) Sociology of Opinion Formation (3)
442. Special Topics in Advertising (3)
443. Advertising Campaigns (3)
444. Advertising in Contemporary Society (3) *Mr. Norris*
460. Photography for the Mass Media (3) *Mr. Leos*
466. Public Relations Problems (3) *Mr. Gibbs*
468. Law of Mass Communications (3) *Mr. Smith*
470. Reporting of Contemporary Issues (3)
481. News Editing and Evaluation (3)
492. Public Affairs Broadcasting (3) *Mr. Farson*
499. Independent Study in Mass Communication (2-6) *Staff*

504. Seminar in the History of Mass Communication (3) *Mr. Harrison*

505. International Communication Problems (3) Legal and communications problems of the international flow of news and opinion; international press codes.

506. Introduction to Mass Communications Research (3) The scientific method; survey of basic concepts of theoretical and empirical research; variety of methodology; criteria for adequate research. *Mr. Barnes*

508. The Literature of Journalism (3)

510. Mass Communications Research Methods I (3) Design of research on processes and effects of mass communications; data analysis and hypothesis testing. Prerequisite: Journ. 506 or Stat. 400. *Mr. Barnes*

511. Mass Communications Research Methods II (3) Problems of bibliographical research; evaluation of sources and materials in mass communications history, biography, structure, ethics, and other areas. Prerequisite: Journ. 506.

513. Constitutional Problems of the News Media (3) Problems involving conflict between guarantees of press freedom in the First and Fourteenth Amendments and rights and privileges of others. *Mr. Harrison*

521. News Media and Public Opinion (3) Problems in the function, techniques, and responsibilities of press, radio, and television in forming and interpreting opinion. Prerequisite: Pl.Sc. 427. *Mr. Pockrass*

524. Government and Mass Communications (3) Problems of freedom of information; governmental efforts to control mass communication agencies; government news coverage; public information agencies. *Mr. Smith*

540. Seminar in Advertising Problems (3) *Mr. Norris*

545. Advertising and Consumer Behavior (3) Examination of theories of human behavior as they apply to the study of advertising's effects on consumer behavior.

585. Comparative Theories of Press Systems (3) Institutional structure and normative functions of press systems in modern societies, as shaped by prevailing world view and social organization. *Mr. Norris*

LABORATORY ANIMAL MEDICINE (L A M)

C. Max Lang, *Chairman, Department of Comparative Medicine*
The Milton S. Hershey Medical Center

Degree Conferred: M.S.

Graduate Faculty: Senior Member Lang.
Graduate Faculty: Associate Members Andrews, Bullock, and Hughes.

The department offers a postdoctoral program for veterinarians leading to the Master of Science degree with a major in laboratory animal medicine. Laboratory animal medicine is a specialty of veterinary medicine that is concerned with the biology of laboratory animals and their comparative relationships to man. Postdoctoral training in this discipline provides a broad, basic foundation upon which the individual can build a career in teaching and research in laboratory animal medicine and/or in the professional direction of research animal facilities. The program has a strong research-oriented base with emphasis on comparative medicine and pathology.

The program requires two years for completion. Basically, the first year consists of formal course work, while the second year is devoted mainly to research and the development of clinical skills and techniques. A student must have earned a minimum of 12 credits in a major subject, 6 credits in a minor subject, and 6 credits of thesis research in order to receive the graduate degree. Approved minors have been established in anatomy, behavioral science, biological chemistry, microbiology, pathology, pharmacology, and physiology.

Students with a 2.75 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.75 grade-point average may be made for students with special backgrounds, abilities, and interests.

This program is offered only at The Milton S. Hershey Medical Center.

COMPARATIVE MEDICINE (C MED)

501. Biology and Care of Laboratory Animals (2) Presentation of the anatomic and physiologic characteristics of the commonly used laboratory animal species and their relation to biomedical research.

503. Laboratory Animal Genetics (2) Genetic principles applied to laboratory animals used for investigations of diseases that may be controlled or influenced by genetic factors.

505. Laboratory Animal Zoonoses (2) Experimentally induced, spontaneous, and infectious diseases transmissible between man and animals with special emphasis on etiology, differential diagnosis, and control.

507. TECHNIQUES OF LABORATORY ANIMAL EXPERIMENTATION (2) Techniques of drug administration, infusion, and collection of body fluids and materials; gnotobiology; use of radioisotopes and bioinstrumentation.

510. ANIMAL PHYSIOLOGICAL SURGERY (3) Selected operative procedures, demonstrating principles of physiology with modern biomedical instrumentation, will be followed through the postoperative period.

515. EXPERIMENTAL SURGERY OF LABORATORY ANIMALS (3) Surgical techniques, including nephrectomy and Goldblatt clamp, bladder and gastric pouches, bile duct cannulation, intraventricular operation, cardiac and cerebrovascular catheterization.

530. DISEASES OF LABORATORY ANIMALS, I (3) Physiological and pathological expressions of both infectious and metabolic-degenerative disease of rodents, with emphasis on diagnostic and control methods.

531. DISEASES OF LABORATORY ANIMALS, II (3) Physiological and pathological expressions of both infectious and metabolic-degenerative disease of nonhuman primates and other species of animals.

535. COMPARATIVE PATHOLOGY (3) Comparative pathologic characteristics of infectious and metabolic disease of animals and man.

540. SEMINAR (1 per term) Student and faculty discussions of organization and presentation of data on recent advances in selected topics of laboratory animal medicine.

570. SPECIAL TOPICS (1-6) Specialized training in advanced research techniques and current status of research in the various areas of laboratory animal medicine.

LINGUISTICS (LING)

SIMON BELASCO, *In Charge of Graduate Programs in Linguistics*
309 Burrowes Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Belasco, Borden, Brault, Brubaker, Cofer, Dalbor, Ebbinghaus, Hammer, Holtzman, Magner, Martin, Morrill, Palermo, Schmalstieg, and Sturcken.
Graduate Faculty: Associate Member Schnitzer.

A student majoring in linguistics may specialize in one of several flexible interdisciplinary graduate programs. The M.A. degree program includes general courses in historical linguistics, generative phonology and syntax, psycholinguistics, and acoustic phonetics. A candidate will also select, with the help of his graduate adviser, a coherent set of electives in a specialized area which may be a language or a related field. He will submit an acceptable thesis or paper and pass a written comprehensive examination.

In addition to the courses required for the M.A. degree in linguistics (or the equivalent), each candidate for the Ph.D. degree must take the following courses: Ling. 503 if he has selected Ling. 504 or vice-versa, Ling. 505 (Seminar in Historical Linguistics), Spch. 520 (Seminar in Speech Science), and at least two 500-level courses in the structure, phonology, and history of a language or language family other than his native language if he specializes in a related area, and at least five 500-level courses in the related area. If he specializes in a language area, he must take at least two 500-level courses in the structure, phonology, and history of a language or language family other than his native language or language area and at least five 500-level courses in his language area. The specialized area will be selected by the candidate with the approval of his doctoral committee. The doctoral comprehensive examinations will be both written and oral and will cover the synchronic and diachronic aspects of general linguistics as well as the candidate's specialized area. The thesis must represent a significant contribution to linguistic knowledge. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of either French, German, Spanish, or Russian and another major language related to the candidate's professional interests.

The minimum requirement for admission to an advanced degree program will normally be a B.A. degree in linguistics or an equivalent in any of the interdisciplinary subjects recognized as a specialized area.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

LINGUISTICS (LING)

400. Introduction to Transformation Grammar (3)
402. Historical Linguistics (3)
404. Generative Phonology (3)
413. (Spch. 413) Experimental Linguistics (3)
420. (Psy. 420) Advanced Psycholinguistics (3)
448. Language Variation (3)
449. Problems in Transformational Semantics (3)
451. (Greek 451) History of the Greek Language (3)
461. (Latin 461) History of the Latin Language (3)

500. Generative Linguistics (3) Types of grammatical rules and their interrelations; algorithm for assigning structural descriptions; evaluation procedure for selecting best compatible grammar.

503. Generative Syntax (3) Grammatical rules specifying well-formed strings; conditions on analyzability and assigning of structural descriptions; deviation from well-formedness. Prerequisite: Ling. 400.

504. Generative Phonology (3) Distinctive feature theory in the generative framework; articulatory and acoustic correlates; nonphonemic features. Prerequisite: Ling. 400.

505. Seminar in Historical Linguistics (3) Detailed study of some problem of historical linguistics, e.g., the laryngeal theory, Indo-European ablaut, etc. Prerequisite: one course in historical linguistics.

520. (Psy. 520) Seminar in Psycholinguistics (3) The relationship between the behavioral, probabilistic view and the structuralist, deterministic view of language as a system of habits.

595. Seminar in Interdisciplinary Linguistics (3-12) Methods of research. Common and individual investigations in interdisciplinary fields of linguistics in consultation with one or more interdisciplinary instructors. Prerequisite: Ling. 400.

MAN-ENVIRONMENT RELATIONS (M E R)

Raymond G. Studer, *Director of the Division*
S-126 Human Development Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Arnold, Densmore, Esser, Lawton, Mann, Ritti, Studer, Vallance, and Wohlwill.
Graduate Faculty: Associate Members Coblentz, Everett, Funkhouser, Griffin, Patterson, Powers, and Smith.

Graduate instruction and research opportunities are available in the application of tools and knowledge from the basic sciences to the understanding of man-environment systems and their development to meet human needs. This interdisciplinary program focuses upon issues related to the planning, design, management, and evaluation of environmental support systems for various human settings. Drawing heavily upon basic research in the behavioral sciences, this

program deals extensively with effects of the man-made environment upon human biological, psychological, and social development and functioning.

Students may focus on either environmental-behavioral analysis or environmental-behavioral design and management, and may develop highly individualized courses of study to develop specialized competence. Courses within the division are organized to focus relevant knowledge from basic and applied disciplines on issues of environmental design, planning, management, and behavior analysis, emphasizing the interrelationships among them. Students are encouraged to participate in the course offerings of other programs within the University to complement and support this interdisciplinary focus.

The communication and foreign language requirement for the Ph.D. may be satisfied by options selected from designated areas including but not restricted to foreign languages. The thesis or paper option is available for the M.S. degree, subject to individual approval. Some preparation in statistics is expected; however, deficiencies in this and other areas may be removed concurrent with graduate studies.

Undergraduate preparation may be in relevant areas of the physical, behavioral or social sciences, or in environmental and urban studies. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

FOOD SERVICE AND HOUSING ADMINISTRATION (FS HA)

402. Food Service and Housing Layout and Design (3)
410. Advanced Quantity Food Production (3)
412. Food and Beverage Operations (3)
435. Financial Management in Hospitality Industries (3)
442. Hospitality Merchandising (3)
461. Personnel Functions in Food Service and Housing Administration (3)
470. Problems in Food Service and Housing Administration (3)

MAN-ENVIRONMENT RELATIONS (M E R)

400. Problems in Man-Environment Relations (1-6)
408. Intermediate Textiles (3)
409. Intermediate Textiles Laboratory (1-3)
410. Dimensions of Clothing Behavior (3)
415. Functional Clothing Design (3-12)
416. Western Costume Development From the Renaissance to the Present (3)
432. Behavioral Aspects of Man-Environment Relations II (3)
442. Analytic Methods in Man-Environment Relations II (3)
452. Man-Environment Relations Laboratory II (3)
453. Man-Environment Relations Laboratory III (3)
471. Housing Space Related to Living Patterns (3)
472. Housing Problems and Policies (3)

500. Nonthesis Research (1-6)

501. Problems in Man-Environment Relations (1-9) Individual directed study, investigation and practice in selected aspects of man-environment relations.

502. Seminar in Man-Environment Relations (1-9)

503. Research Methods and Evaluation in Man-Environment Relations (1-9)

505. Environmental-Behavioral Programming, Design, and Management (3) Applications of findings in the behavioral sciences to environmental design and management strategies; empirical, theoretical, and methodological issues.

510. Psychological Foundations of the Study of Environment-Behavior Relations (3) Seminar relating the psychology of perception, cognition, motivation, personality, attitude formation, and psychological stress to aspects of the physical environment.

515. Environmental Systems Theory (3) An in-depth review of those elements of general systems theory relevant to the analysis and organization of man-environment settings.

516. Quantitative Methods in Environmental Management (3) The use of operations research and systems analysis in the modeling of man-environment systems. Prerequisite: M.E.R. 515.

520. Recent Developments in Textiles (3) Developments in fibers, yarns, fabrics, finishes; effects on use and care; discussions and reports based on current literature.

521. Clothing Behavior (3) Analysis and interpretation of clothing behavior through application of theories selected from the behavioral sciences.

522. Clothing Production, Distribution and Consumption Systems (3) Problems connected with manufacture and consumption of clothing; interrelation of textile and clothing trades with other industries.

523. Societal Determinants in Clothing and Textile Development (1-6)

525. Textile Technology (6)

540. The Proximate Housing Environment (3) Evaluation of useful objects in respect to their form, function, and time; selection for exhibition.

541. Aesthetic Aspects of Housing (3) Approach based upon human needs with consideration of materials in the light of their use in home living.

MATHEMATICS (MATH)

Paul Axt, *Head of the Department*
227 McAllister Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty: Senior Members Andrews, Armentrout, Axt, C. Ayoub, R. Ayoub, S. Chowla, Deutsch, Fine, Grilliot, Hahn, Hammer, Hunter, James, Kanwal, A. Krall, Lallement, Lubkin, Morris, Petrich, Ribeiro, Rung, and Wells.
Graduate Faculty: Associate Members Brownawell, Chang, Huff, Kalmbach, Mack, Mansfield, Maserick, McCammon, McLaughlin, Olson, Parsons, Schneider, and Stevens.

Graduate courses in all the principal branches of mathematics are offered regularly each year. The department is prepared to direct research in a variety of fields, including various branches of analysis, algebra, topology, number theory, numerical analysis, applied analysis, algebraic geometry, and mathematical logic and foundations.

To be admitted to the Ph.D., D.Ed., or M.A. program without undergraduate deficiency, an applicant should have completed at least 18 credits in mathematics at the advanced undergraduate level (400 series or their equivalents). The undergraduate student is urged to take at least 6 credits in foundations of analysis (Math. 420-421) and 6 in modern algebra (Math. 480-481) or their equivalents. These courses are essential preparation for the graduate program and, if they are taken after admission, at most 6 credits may be counted toward an advanced degree. All first-year students working toward the Ph.D., D.Ed., or M.A. degree are required to enroll in Math. 489 for two successive terms.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

All Ph.D. students must take qualifying examinations in three fields of mathematics and demonstrate a reading knowledge of one foreign language (French, German, or Russian) before they have accumulated 48 graduate credits earned at the University or elsewhere. Recommendations for advancement to Ph.D. candidacy are based on these examinations. The comprehensive examination is given after approximately 60 credits are earned and only after the student has

passed a reading examination in a second of the foregoing languages. The Ph.D. student is also expected to enroll in advanced seminars.

For the D.Ed. degree, a student must pass qualifying examinations in algebra and analysis and a reading examination in French, German, or Russian before he is allowed to take the comprehensive examination. In addition to the major thesis, the department requires participation in two terms of research seminar, but no minor thesis is required. The D.Ed. program is intended for college teachers. Three years of experience in college teaching is required for admission.

For the M.A. degree the department offers two options: (1) The thesis option requires 12 credits of approved 500-series courses in mathematics, 6-9 credits of thesis, sufficient credits in approved 400- or 500-series courses to make a total of 30 credits, and a final oral examination based on the thesis and general course material; and (2) the nonthesis option requires 18 credits of 500-series courses in mathematics with a grade of A or B, sufficient credits in approved 400- or 500-series courses to make a total of 30 credits, and a term paper on an approved topic in mathematics. No final examination is given in this option.

To be admitted to the M.Ed. program without undergraduate deficiency, an applicant should have completed at least 15 credits in mathematics at the intermediate level beyond calculus. The M.Ed. program does not require any 500-series courses, but the student is encouraged to select some at this level. Special courses have been instituted for the training of teachers. Among these are Math. 400, 401-402, 416, 425-426, and 470-471. These are acceptable for the satisfaction of credit requirements only for the M.Ed. degree.

Entering graduate students in mathematics for whom English is not the first language are required to have a score of at least 550 on the TOEFL (Test of English as a Foreign Language) examination. Furthermore, the results of this examination must be received by the Department of Mathematics at least six months prior to the requested date of admission to the Graduate School.

MATHEMATICS (MATH)

400. Probability for Teachers (3)
401-402. Geometry for Teachers (3 each)
404. Theory of Numbers (3)
405. (A.M. 405) Fourier Series and Partial Differential Equations (3)
406. Topics in Theory of Numbers (3)
409-410. (Stat. 409-410) Introduction to Mathematical Statistics (3 each)
411. Finite Differences (3)
412. (Stat. 412) Introduction to Mathematical Statistics (3)
413-414. Mathematics of Science for Teachers (3 each)
416. Mathematical Logic for Teachers (3)
417. (A.M. 417) Tensor Analysis (3)
418. (A.M. 418, Stat. 418) Discrete Probability Theory (3)
420-421. Introduction to Analysis (3 each)
422. Algebraic Geometry (3)
423. Metric Differential Geometry (3)
425-426. Analysis for Teachers (3 each)
427. (Stat. 427) Discrete Stochastic Models (3)
428. (Phil. 428) Logical Theory (3)
429. General Topology (3)
430. Elementary Algebraic Topology (3)
431. (A.M. 431) Ordinary Differential Equations (3)
435. Axiomatic Set Theory (3)
441. (A.M. 441) Matrix Algebra (3)
452. (A.M. 452) Functions of a Complex Variable (3)
453. (Cmp.Sc. 453) Numerical Computations (3)
454. (Cmp.Sc. 454) Matrix Computations (3)
470-471. Algebra for Teachers (3 each)
472. Foundations of Geometry (3)

480-481. Introduction to Modern Algebra (3 each)
489. Mathematics Seminar (1-6)
490. Topics in Mathematics (3-9)
491. Topics in Applied Mathematics (3-9)

501-502. Theory of Functions of a Real Variable (3 each) Sets, metric spaces, measure and integration, Lp spaces and other function spaces, differentiation. Prerequisite: Math. 421.

503. Fourier Analysis (3) Fourier series and integrals, convergence and summability, theorems on Fourier coefficients, uniqueness properties. Prerequisite or concurrent: Math. 502.

505. Integral Equations (3) Fredholm and Volterra equations, and applications. Prerequisite: Math. 421.

507. Calculus of Variations (3) Prerequisite: Math. 421.

508-509. Complex Analysis (3 each) Analytic and meromorphic functions; Riemann's mapping theorem. Prerequisite: Math. 421.

511. Linear Algebra (3) Vector spaces and linear transformations, canonical representations, elementary divisors and invariant factors. Prerequisite: Math. 481 or 537.

515. Partial Differential Equations of Mathematical Physics (3) Methods of solution of selected elliptic, parabolic, and hyperbolic partial differential equations, with reference to physical application. Prerequisite: Math. 421.

517-518. (Stat. 517-518) Probability Theory (3 each) Measure theoretic foundation of probability, distribution functions and laws, types of convergence, central limit problem, conditional probability, special topics. Prerequisites: Math. 452, 501.

520. Projective Geometry (3) General study of the subject from the synthetic and analytic standpoint. Prerequisites: Math. 472, 480.

523. Differential Geometry (3) Manifolds-differentiable structures, tangent spaces, connections, structural equations, Riemannian geometry. Prerequisite: Math. 429.

524. Advanced Complex Analysis (3) Topics include boundary behavior of analytic functions, bounded analytic functions, conformal mapping, theory of Riemann surfaces. Prerequisite: Math. 509.

525. Theory of Functions of Several Complex Variables (3-6) Topics include fundamental properties of holomorphic functions, complex analytic manifolds, integral representations, Cousin problems. Prerequisite: Math. 509.

526. Theory of Sheaves (3) Presheaves over topological spaces; defining sheaves two ways; Cech cohomology of presheaves; cohomology of sheaves; flasks; Lubkin's punctual cochains. Prerequisites: Math. 429 and 480 or 535.

527. Algebraic Geometry (3) Preschemes and proschemes; products; projective finite and affine presentation maps; projective quasicoherent sheaves; cohomology of quasicoherent sheaves over affine schemes. Prerequisite: Math. 526.

528. Uniform Spaces and Function Spaces (3) Uniform spaces, completion, compactifications, function spaces, metrization. Prerequisite: Math. 429.

529-530-531. Topology (2 each) Topological, product, compact, metric, and connected spaces; continuous functions; separation axioms, countability conditions, combinatory topology.

532. Theory of Sets (3) Formal development of set theory on a logical basis and related methodological problems; applications to the foundations of mathematics. Prerequisite: Math. 428.

535-536-537. Algebra (3 each) Basic theory of semigroups and groups, rings and modules, fields, lattices.

538. Commutative Algebra (3) Topics selected from noetherian rings and modules, primary decompositions, Dedekind domains and ideal theory, other special types of commutative rings or fields. Prerequisite: Math. 536.

539. Rings (3) Selected topics from the theory of rings. Prerequisite: Math. 536.

540. VALUATION THEORY (3) Selected topics from the theory of valuations on a field including completeness, extensions, ramification, local and global fields, adeles and ideles.

542-543. (Stat. 542-543) STATISTICAL DISTRIBUTION THEORY (3 each) Random variables and expectations; discrete, continuous, univariate, multivariate, exact, and asymptotic distribution theory. Prerequisites: Math. 421 and 441 or 481.

547-548-549. LIE THEORY (2 each) Topics selected from theory of topological semigroups, topological groups, lie groups, transformation groups. Prerequisite: Math. 531.

550. (Phil. 550) FOUNDATIONS OF MATHEMATICAL LOGIC (3) The nature of logical basis of mathematics; critical examination and development of the basic parts of logical calculus. Prerequisite: Math. 480 or 428.

552. (Cmp.Sc. 552) NUMERICAL ANALYSIS I (3) Interpolation; remainder theory; approximation of functions; error analysis; orthogonal polynomials; approximation of linear functionals; functional analysis applied to numerical analysis. Prerequisites: Math. 420, 453.

553. (Cmp.Sc. 553) NUMERICAL ANALYSIS II (3) Eigenvalue and eigenvector determination; numerical solution of integral equations and ordinary differential equations with error and stability analysis. Prerequisites: Math. 420; Math. 454 or 481.

554. (Phil. 554) LOGIC AND METAMATHEMATICS I (3) Completeness, Löwenheim-Skolem, Herbrand, and compactness theorems; first-order theories; categoricity, elimination of descriptions; decidability; algebraic and geometric applications. Prerequisite: Math. 428.

556. (Phil. 556) RECURSION THEORY (3) Recursive functions; normal form, enumeration and separation theorems; partial recursive functions; recursion theorems; special recursive functions; alternate formulations; related topics. Prerequisite: Math. 428.

557. (Phil. 557) LOGIC AND METAMATHEMATICS II (3) Arithmetization; Gödel and Tarski incompleteness theorems; undecidability results; Gentzen-type systems and consistency results. Prerequisite: Math. 428.

558-559. (Stat. 558-559) THEORY OF STOCHASTIC PROCESSES (3 each) Stationary, independent, and orthogonal processes; discrete and continuous Markov processes; martingales and semi-martingales applications. Prerequisite: Math. 518.

560-561. THEORY OF DIFFERENTIAL EQUATIONS (3 each) Topics selected from existence and uniqueness of solutions of differential systems, Sturm-Liouville systems, eigenvalue problems, integral operator solution. Prerequisites: Math. 72 or 83 or 100, and 508.

562. THEORY OF SPECIAL FUNCTIONS (3) Topics include asymptotic expansions; Riemann-Papperitz and Trusdell's F equations; orthogonal polynomials; generating, beta, zeta, hypergeometric, Bessel, Legendre, elliptic functions. Prerequisites: Math. 72 or 83 or 100 and either Math. 420 and Math. 452 or Math. 508.

563. (Cmp.Sc. 563) APPROXIMATION THEORY (3) Approximation in normed spaces; existence, uniqueness, characterization, computation of best approximations; error bounds; degree of approximation; approximation of linear functionals. Prerequisites: Math. 453, 501.

564. (Cmp.Sc. 564) NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS (3) Numerical solution of initial and boundary-value problems; eigenvalues and eigenfunctions; errors, stability, and convergence. Prerequisite: Math. 552.

565. FUNCTIONAL ANALYSIS (3) Theory of Banach and Hilbert spaces, including functionals and operators, and related topics. Prerequisite: Math. 502.

570. SPECIAL TOPICS IN GEOMETRY (3-12)

571. SPECIAL TOPICS IN ANALYSIS (3-12)

572. SPECIAL TOPICS IN ALGEBRA (3-12)

573. SPECIAL TOPICS IN APPLIED MATHEMATICS (3-12)

574. SPECIAL TOPICS IN FOUNDATIONS OF MATHEMATICS (3-12)

575-576. MATHEMATICS SEMINAR (1-6 each) Selected topics from recent mathematical developments.

577. (Stat. 577) SPECIAL TOPICS IN PROBABILITY (3-12) Special topics in probability which are not offered regularly but which are of special interest to faculty and students.

578. SPECIAL TOPICS IN TOPOLOGY (3-12)

579. (Cmp.Sc. 579) SPECIAL TOPICS IN NUMERICAL ANALYSIS (2-12)

580. SPECIAL TOPICS IN NUMBER THEORY (2-12)

581-582. GROUP THEORY I, II (3 each) Selected topics from group theory including Abelian, solvable, nilpotent, and free groups, Sylow theorems, and group extensions and representations. Prerequisite: Math. 535.

583. HOMOLOGICAL ALGEBRA (3) Modules, diagrams, functors, homology of complexes, resolutions, cohomology of groups, tensor and torsion products. Prerequisite: Math. 536.

584-585-586. ALGEBRAIC TOPOLOGY (2 each) Development of singular and Cech homology and cohomology theories; homotopy and cohomotopy theories. Prerequisite: Math. 531.

587-588-589. POINT SET TOPOLOGY (2 each) Topics selected from point set topology including upper semicontinuous and continuous decompositions, theory of continua, dimension theory. Prerequisite: Math. 531.

591. (Stat. 591) SEMINAR IN PROBABILITY THEORY (1-6) Lectures on current and recent research in various special topics in probability theory.

592-593-594. NUMBER THEORY (3 each) Congruences, quadratic residues, arithmetical functions, Dirichlet's theorem, prime number theorem, classical multiplicative ideal theory, partitions, valuations and p-adic numbers, divisors. Prerequisite: Math. 480. Prerequisite or concurrent: Math. 508.

NOTE: *Courses in Applied Mathematics, Computer Science, and Statistics are listed separately.*

MATHEMATICS (MATH)

HELMUT E. WEBER, *In charge of Graduate Program in Mathematics*
King of Prussia Graduate Center, King of Prussia, Pa. 19406

Degree Conferred: M.Ed.

Graduate Faculty: Associate Members Callahan, Duncan, and Llorens.

The program is offered specifically to permit teachers in the area to pursue advanced studies through evening classes while employed in teaching. Courses offered for the program are established and controlled by the resident departments at the University Park Campus.

Credit requirements may be satisfied by completing a minimum of 18 credits in approved mathematics courses, a minimum of 6 credits in approved mathematics and science courses, and a minimum of 6 credits in approved education courses. In addition, a term paper is required. All requirements must be met within six years or seven consecutive summers.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. An applicant must have a bachelor's degree and have completed 27 credits in mathematics including at least 15 credits at the intermediate level beyond calculus. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Further details concerning this program may be obtained by writing directly to the Graduate Center.

MECHANICAL ENGINEERING (M E)

DONALD R. OLSON, *Head of the Department*
207 Mechanical Engineering Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Brickman, Brighton, Cunningham, Di Ilio, Faeth, Heinsohn, Lestz, McLaughlin, Meyer, Moroz, Olson, Reethof, Schmidt, Shearer, and Wolgemuth.
Graduate Faculty: Associate Members DeCarolis, Henry, Kuo, Matsumoto, Park, Parke, and Wambold.

Graduate programs and research facilities are available in thermodynamics and combustion, heat transfer, fluid mechanics, dynamic system analysis, mechanical design, biomedical engineering, automatic controls, and fluid amplifiers. Air pollution control, automotive safety, designing for noise control and for reliability also provide many research and design opportunities.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by an in-depth study of one foreign language (9-12 credits) or by demonstrating competence in translating the technical literature in two foreign languages; or by taking three or more courses (minimum of 9 credits) of a nontechnical nature in a single area of study appropriate and related to the student's career orientation.

A student working toward an M.S. degree may choose one of the following options: (1) a minimum of 24 course credits plus 6 thesis credits (M.E. 600) culminating in the submission of a thesis to the Graduate School or (2) a minimum of 30 course credits plus submission of a scholarly written report to the department. A Ph.D. thesis research proposal may serve as the written report provided the student has passed the candidacy examination.

The entering student must hold a bachelor's degree in engineering or physical science. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

MECHANICAL ENGINEERING (M E)

401. MECHANICAL ENGINEERING (3-12)
402. AIR CONDITIONING AND LIFE SUPPORT SYSTEMS (3)
403. ROCKET PROPULSION (3)
405. SMALL PARTICLE TECHNOLOGY (3)
409. GAS TURBINES (3)
410. POWER PLANTS (3)
411. REFRIGERATION (3)
412. HEAT TRANSFER (3)
413. INTERNAL COMBUSTION ENGINES (3)
417. THEORY OF ENGINEERING INSTRUMENTS (3)
418. PRINCIPLES OF TURBOMACHINERY (3)
421. (Aersp. 421) INTERMEDIATE VISCOUS FLOW (3)
450. DESIGN OF MACHINE TOOLS (3)
451. ADVANCED MACHINE DESIGN PROBLEMS (3)
452. DESIGN ANALYSIS (3)
455. AUTOMATIC CONTROL SYSTEMS (3)
458. NOISE CONTROL IN MACHINERY (3)
460. RELIABILITY CONCEPTS IN DESIGN (3)
470. INTRODUCTION TO AIR POLLUTION CONTROL (3)
472. ENGINEERING AND ADMINISTRATION OF AIR POLLUTION CONTROL (8)

503. THERMODYNAMIC PROCESS ANALYSIS (3) Development of equations governing separate processes in complete machines to give basic system parameters and characteristics; transient processes; irreversible effects.

504. ADVANCED ENGINEERING THERMODYNAMICS (3-6) Pure and applied thermodynamics including its application to advanced engineering problems; collateral reading and discussion of the classical works on the subject.

506. SELECTED TOPICS IN MECHANICAL ENGINEERING (1-12) Advanced courses adapted to the individual requirements of graduates in mechanical engineering.

512. HEAT TRANSFER — CONDUCTION (3) One- and two-dimensional conduction heat transfer for steady state and transient systems with varying boundary conditions.

513. HEAT TRANSFER — CONVECTION (3) Laminar and turbulent flow heat transfer in natural and forced convection systems.

514. HEAT TRANSFER — RADIATION (3) Thermal radiation fundamentals; specular and diffuse systems; differential and integral methods; numerical techniques; industrial applications.

519. COMPRESSIBLE FLUID FLOW (2-4) Two-dimensional subsonic flow; similarity rules; theory of characteristics; supersonic and hypersonic flows; nonsteady flow; oblique shock waves.

521. ELECTROMAGNETIC AND THERMODYNAMIC FLOW SYSTEMS (3) Thermodynamic equations for flow of reacting and nonreacting fluids in electromagnetic fields; applications to engineering problems.

522. BOUNDARY LAYER AND SEPARATED FLOWS (3) Behavior of viscous fluids, with emphasis on boundary layer and separation effects in internal flow.

540. SIMULATION OF MECHANICAL ENGINEERING PHENOMENA (3) Analog and numerical methods for simulation of problems in thermodynamics, heat transfer, fluid mechanics, diffusion, and machine dynamics.

552. ADVANCED DYNAMICS OF MACHINES (3-6) Linear and torsional vibrations in and balancing of rotating and reciprocating machinery; exact analysis of stresses produced by these and other dynamic forces in machine parts. Prerequisites: E.Mch. 12, M.E. 54.

553. FRICTION AND LUBRICATION (3) Sliding and rolling surface phenomena; hydrostatic, hydrodynamic, and magnetohydrodynamic lubrication theory; design and control of gas and fluid lubricated bearings.

555. AUTOMATIC CONTROL SYSTEMS (3) Advanced problems and techniques in the design of automatic control systems with emphasis on stability, controller design, and optimum performance. Prerequisite: M.E. 455.

556. ADVANCES IN CONTROL SYSTEMS ANALYSES (3) Control system theory and applications of newly developed theory to engineering systems; nonlinear systems, distributed systems, state-space methods. Prerequisite: M.E. 555.

557. MECHANISM SYNTHESIS (3) Geometrical and algebraic methods for synthesizing planar and spatial mechanisms, dynamics of spatial mechanism.

558. FLUID CONTROL SYSTEMS (3) Systems elements, simplified models, analysis of interacting elements, instrumentation; computer-aided case study, and experimental investigations. Prerequisite: M.E. 455.

560. PROBABILISTIC METHODS IN MACHINE DESIGN (3) Reliability determination of machines for various types of interfering stress and strength probability functions. Probabilistic life consumed modeling. Prerequisites: Math. 409 or M.E. 460 or I.E. 323, M.E. 42, 54.

571. AIR POLLUTION SEMINARS (1-2) Weekly seminars featuring the contributions of many different disciplines to the solution of air pollution and other environmental problems.

580. INVESTIGATION PROJECTS (2-6) Special experimental studies or investigations in mechanical engineering, adapted to individual requirements.

METALLURGY (METAL)

WILLIAM R. BITLER, *In Charge of Graduate Programs in Metallurgy*
221 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Bitler, Healy, Hoke, Muan, Ryba, and Simkovich.
Graduate Faculty: Associate Member Pickering.

This program is one of the options in which a graduate student in the Department of Material Sciences can receive an advanced degree. A student may specialize, through both course work and research, in the science and engineering aspects of chemical, physical, or mechanical metallurgy.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language together with courses from other designated areas.

Suitable preparation for graduate study in this program may be found in one of the material sciences such as ceramic science, fuel science, metallurgy, or solid state science; in engineering fields such as chemical or mechanical engineering; in basic physical sciences such as chemistry or physics; or in earth sciences such as geochemistry and mineralogy. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

METALLURGY (METAL)

401. METALLURGICAL PROCESSES AND KINETICS (3)
402. ELECTROMETALLURGY, HYDROMETALLURGY, AND CORROSION (3)
403. ANALYTICAL METALLURGY
404. PYROMETALLURGY (3)
405. PHYSICAL METALLURGY (3)
406. METALLOGRAPHY (3)
407. METALLURGICAL ENGINEERING I (3)
408. METALLURGICAL ENGINEERING II (3)
410. METALLURGICAL INVESTIGATIONS II (3)
412. SOLID-STATE METALLURGY (3)
420. PARTICULATE SYSTEMS IN MINERAL PROCESSING (3)
421. PARTICLE TECHNOLOGY LABORATORY (1-3)
423. RECENT DEVELOPMENTS IN MINERAL PROCESSING (3)
424. (Min.E. 424) COAL PREPARATION (3)
425. INTERFACIAL PHENOMENA AND FLOTATION (3)
459. METALLURGICAL APPLICATIONS FOR ENGINEERS (3)
460. POLLUTION CONTROL IN THE MINERAL PROCESS INDUSTRIES (3)

501. METALLURGICAL PROBLEMS (1-6 per term) Independent study of special problems in metallurgy.

502. SEMINAR IN METALLURGY (1-6) Conferences, reading, reports, and special lectures.

508. KINETICS OF PHASE TRANSFORMATIONS (3) Application of statistical mechanics and absolute rate theory to kinetics of phase transformations, including diffusion, nucleation, and growth rates. *Mr. Bitler*

509. INTRODUCTORY THEORETICAL PHYSICAL METALLURGY (3) Quantum mechanics and its application to solid-state theory; introduction of Schroedinger's equation, its solutions, free-electron model, band model. *Mr. Bitler*

510. Magnetic and Transport Properties of Materials (3) Treatment of the magnetic and transport properties of solids by quantum mechanics with applications to practical alloy development. Prerequisite: Metal. 509. *Mr. Bitler*

511. Advanced Physical Metallurgy (3) Physical metallurgy of an advanced nature; consideration of solid state bonding, crystal structure, alloy constitution. Prerequisite: Metal. 509. *Mr. Ryba*

513. Advanced Chemical Metallurgy I (3) Application of thermodynamics and kinetics to the heterogeneous metallurgical processes of oxidation, reduction, smelting, and refining. Prerequisites: Chem. 452, Metal. 301, 402, 404. *Mr. Healy*

514. Dislocation Theory (3) Self and interaction energies of dislocations and other defect structures; dislocation motions and their relation to mechanical properties. *Mr. Bitler*

515. Corrosion of Metals (3) Phenomena and theories of metallic corrosion; principles of alloy selection for engineering and structural uses in corrosive environments. *Mr. Pickering*

516. Flow and Fracture of Solids (3) Phenomenological and theoretical treatment of flow and fracture in solids. Prerequisites: Metal. 511, 514. *Mr. Hoke*

518. Heterogeneous Equilibria at High Temperatures (2-3) Treatment of high-temperature equilibria in metal and oxide systems involving crystalline, liquid, and gas phases. Prerequisite: Metal. 513. *Mr. Muan*

519. Advanced Chemical Metallurgy II (3) Application of thermodynamics and kinetics to precipitation of nonmetallic and metallic phases from liquid and solid metals at elevated temperatures. Prerequisite: Metal. 513. *Mr. Healy*

520. Foundry Metallurgy (3) Physical-chemical considerations of the liquid state, solidification, and the solid state as applied to casting of metals and alloys. Prerequisites: Metal. 511, 513.

522. Solid-Phase Reactions in Metals (3) Mechanisms and rate determining factors in solid-phase reactions in metals; diffusion processes, nucleation theory, precipitations from solid solution, eutectoid decomposition and order-disorder phenomena. Prerequisites: Metal. 508, 511. *Mr. Bitler*

535. (E.Mch. 535) Crystal Defects and Mechanical Response (3) Mechanical responses of crystalline solids containing point, line, and interfacial defects; elastic and plastic responses. Prerequisite: Metal. 514 or E.Mch. 414.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in metallurgical studies are listed under Materials Science.*

METEOROLOGY (METEO)

Alfred K. Blackadar, *Head of the Department*
503 Deike Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Blackadar, Dutton, Hosler, and Panofsky.
Graduate Faculty: Associate Members Anthes, Hovermale, Lavoie, J. Pena, R. Pena, and Thomson.

Candidates may specialize in the study of problems in either theoretical or applied meteorology including such areas as cloud physics, various phases of dynamic meteorology and geophysical fluid dynamics including turbulence and atmospheric circulation, numerical modeling, macro- and microclimatology, synoptic meteorology, or meteorological instrumentation. The department also encourages interdisciplinary studies in such fields as agricultural meteorology, biometeorology, water resources, air pollution, and fluid mechanics.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language (French, German, or Russian). The thesis or paper option is available for the M.S. degree.

Requirements for admission include mathematics through differential equations and one year of college physics. Undergraduate study of meteorology is not required for admission. Special programs are available to encourage the graduate study of meteorology by all students with strong backgrounds in mathematics, physics, or engineering. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

METEOROLOGY (METEO)

400. Meteorology for Teachers (3)
401. Physical Climatology for Teachers (3)
402. Biometeorology for Teachers (2)
403. Science Projects in Meteorology (1)
404. Motions of the Atmosphere and Oceans (3)
407. Elements of Physical Oceanography (3)
411. Introduction to Synoptic Meteorology (3)
418. Introductory Physics of the Upper Atmosphere (3)
420. Tropical Meteorology (3)
430. Introduction to Synoptic Meteorology Laboratory (3)
431. Synoptic Meteorology Laboratory I (3)
432. Synoptic Meteorology Laboratory II (2-10)
433. Advanced Synoptic Analytical Techniques (3)
434. Application of Meteorological Satellite Data to Analysis and Forecasting (3)
443. Physical Meteorology (3)
445. Hydrology for Meteorologists (3)
450. Applications of Statistics to Meteorology (3)
451. Introduction to Dynamic Meteorology (3)
452. Hydrodynamics of the Atmosphere (3)
453. Atmospheric Thermodynamics (3)
461. Theory of Meteorological Instruments (3)
472. Physical and Dynamic Climatology (3)
473. Introduction to Micrometeorology (3)

500. Meteorological Seminar (1-3) Discussion of meteorological reports and papers; scientific outlook. Prerequisites: Meteo. 411, 451.

502. Selected Topics of Advanced Meteorology (1-3 per term) Current problems in meteorology. Prerequisite: a minimum of 15 credits in meteorology.

503. Atmospheric Turbulence (3) Atmospheric diffusion, heat conduction, friction, and evaporation; statistical properties of turbulence.

505. Bioclimatology (2) Climatic phenomena in their relation to life. Prerequisite: Meteo. 472.

506. Advanced Meteorological Analysis (2-6) Physical analysis of atmospheric phenomena; synoptic analysis of weather phenomena for advanced students.

507. Dynamic Oceanography (2) Physical properties of sea water; heat balance of the oceans; theory and observations of ocean currents, waves, and tides.

508. Physics of the Upper Atmosphere (2) Temperature distribution, composition, and electrical characteristics of the upper atmosphere; theories of aurora and light of the night sky.

509. Theoretical Climatology (2) Theory of latitudinal, annual, and diurnal temperature changes; theories of climatic changes, microclimate.

510. Cloud Physics (2) Current theories on phase changes in clouds and mechanisms responsible for precipitation; techniques of cloud modification and control.

511. CLOUD DYNAMICS (2) Study of the structure of cloud-scale motions; numerical models of cumulus clouds; thunderstorms, hailstorms, tornadoes, mesoscale organization of convection. Prerequisite: Meteo. 453.

520. INDIRECT ATMOSPHERIC PROBING (3) Analysis and description of measurements made with radar and bistatic radio, optical and acoustic systems used for indirect atmospheric sounding. Prerequisite: Meteo. 443.

545. SNOW HYDROLOGY (2) Importance of snow in meteorology and the hydrologic cycle; snow properties, metamorphism, prediction of snowmelt runoff, and snow management potentials.

550. ATMOSPHERIC MOTIONS (3) Fundamental properties and conservation requirements of the hydrodynamic equations; elements of advanced dynamic meteorology and applications to atmospheric dynamics. Prerequisite or concurrent: A.M. 451.

551. ATMOSPHERIC WAVE MOTION (2) From classical and physical hydrodynamics to the numerical prediction of wave motion in a baroclinic atmosphere. Prerequisite: Meteo. 452.

552. ADVANCED ATMOSPHERIC DYNAMICS (2) Numerical prediction models, general circulation, thermal and gravitational tides in a spherical shell, and empirical orthogonal functions of statistical forecasting. Prerequisite: Meteo. 551.

553. ENERGETICS OF ATMOSPHERIC MOTION (2) Theoretical investigation of the conversions of energy in the atmosphere; maintenance of the general circulation. Prerequisite: Meteo. 452.

555. ATMOSPHERIC DIFFUSION (2-3) Dispersion of atmospheric contaminants; experiments, theory and practical implications for air pollution problems. Prerequisite: 3 credits of statistics.

561. CHEMISTRY OF THE ATMOSPHERE (2) Fundamental knowledge of chemical characteristics of atmospheric components and transformations, in connection with cloud microphysics, circulation, and air pollution. Prerequisite: 3 credits in chemistry.

NOTE: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in meteorological studies are listed under Materials Science.*

MICROBIOLOGY (MICRB)

LEONARD N. ZIMMERMAN, *Acting Head of the Department*
S-101 Frear Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Casida, Ceglowski, Lindstrom, Ludwig, Stone, Tershak, and Zimmerman.

Graduate Faculty: Associate Members Brenchley, Docherty, Fung, Kolenbrander, Pootjes, and Zarkower.

Specialized areas of study in microbiology include cytology, ecology, food, genetics, immunology, physiology, virology (both animal and bacterial), and environmental and industrial microbiology. There is opportunity for cooperative research with other departments.

The communication and foreign language requirement for the Ph.D. may be satisfied by intermediate knowledge of one foreign language (French, German, or Russian).

Prerequisites for admission are 16 credits in inorganic and organic chemistry, 6 in physics, 8 in microbiology, and mathematics through calculus. Admission may be granted with deficiencies up to 8 credits, to be made up while pursuing graduate work. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. A satisfactory score on the Graduate Record Examination is required for admission.

MICROBIOLOGY (MICRB)

400. Introductory Environmental Microbiology (4)
401. Advanced Bacteriology (4)
407. Problems in Microbiology (1-12)
410. Immunology and Serology (3)
411. Survey of Microbiology (1 per term)
413. Microbial Soil Ecology (3)
414. Food Microbiology (2-4)
415. Introduction to Animal Viruses (2-4)
416. Industrial Microbiology (2-4)
417. Epidemiology (2)
418. Bacterial Viruses (2-4)
470. General Microbiology for Science Teachers (4)

507. Seminar (1 per term) Reports on current fields of research.

508. Bacterial Physiology (2-4) Contributions of environment, finestructure, and metabolism to the functioning cell. Prerequisite: 6 credits of biochemistry.

510. Experimental Immunology (4) The nature of the immune response with emphasis on modern concepts and techniques. Students should have some background in immunology.

511. Special Topics in Microbiology (1-6)

512. Microbiological Methods (1-6) Practice in special laboratory techniques of modern microbiology.

516. Bacterial Genetics (2-4) Mechanisms of variation in microorganisms including mutation, adaptation, sexual recombination, transduction, and transforming factors. Prerequisite: 3 credits each in microbiology and genetics.

520. Biochemical Virology (2) Role of enzymes and nucleic acids in virus synthesis. Regulation of virus reproduction in animal and bacterial cells. Prerequisite: 6 credits of biochemistry.

529. (C.E. 579) Aquatic Microbiology (3) Ecology and physiology of microorganisms of inland waters, estuaries, and oceans; microbiology of wastewater treatment. Prerequisite: introductory microbiology.

MICROBIOLOGY (MICRB)

Fred Rapp, *Chairman of the Department*
The Milton S. Hershey Medical Center

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Member Rapp.
Graduate Faculty: Associate Members Barnes, Duff, Funk, Glaser, and Lausch.

The graduate program is oriented to the study of any aspect of microbiology, especially the general areas of bacteriology, virology, immunology, genetics, and viral oncology. Subdivisions of these disciplines are also available, and many problems in these areas are under investigation by members of the faculty.

The communication and foreign language requirement may be satisfied by one foreign language such as French, German, or Russian. Courses in creative writing, computer science, or statistics can be substituted with permission.

Qualified students with undergraduate preparation in either the biological, biochemical, or physical sciences may apply. A reasonable background in biology, chemistry, and mathematics is required, although it will be possible to strengthen the background in any of these areas during the first year in the graduate program. Programs leading to advanced degrees will be tailored to the background and individual needs of the candidates.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Two letters of recommendation are required and a personal interview is desirable.

This program is offered only at The Milton S. Hershey Medical Center.

MICROBIOLOGY (MICRB)

551. MEDICAL MICROBIOLOGY (3) Principles of microbiology; viruses, rickettsia, bacteria, and fungi as agents of disease. Introduction of microbial genetics, epidemiology, and immune mechanisms.

552. MEDICAL MICROBIOLOGY LABORATORY (2) Laboratory exercises to augment Micrb. 551. Laboratory tests used to characterize microorganisms and to aid in diagnosis of disease.

553. SCIENCE OF VIROLOGY (3) Replication of viruses and effect on host, including transfer of genetic information, immunology, and oncogenic properties of viruses.

554. IMMUNOLOGY OF INFECTION (3) The nature of antigens and antibodies, humoral and cellular immune response governing histocompatability, transplantation, tolerance, and autoimmune disease.

555. MICROBIAL PHYSIOLOGY AND METABOLISM (3) Physiology and comparative biochemistry of microorganisms, especially human pathogens. Concepts of genetic regulation and balanced growth applied to cell replication.

556. MICROBIAL GENETICS (3) Genetics of microorganisms, including gene mapping, lysogeny, information transfer, and viral carcinogenesis.

557. ELECTRON MICROSCOPY (3) The application of electron microscopy to microbiology, including specimen preparation, use of the electron microscope, and photography. Prerequisite: admission to the medical or graduate program and permission of instructor.

570. TOPICS IN MICROBIOLOGY (2 per term) Lectures and seminars concerning current developments in microbiology.

571. SEMINAR IN MICROBIOLOGY (1 per term) Weekly presentations by faculty and postdoctoral and predoctoral trainees of current work in the department.

572. LITERATURE REPORTS (1 per term) Weekly analysis of current literature in microbiology.

573. SELECTED READINGS (2 per term, maximum of 6) Supervised reading program of pertinent literature in microbiology and related scientific fields.

580. LABORATORY EXPERIMENTS IN MICROBIOLOGY (2-6 per term) Laboratory exercises in microbiology, including cell culture, microscopy, radioisotope and other biochemical procedures, serology, and genetic techniques.

581. SPECIAL PROJECTS IN MICROBIOLOGY (2-6 per term) Research projects carried out by graduate students under supervision of a member of the faculty.

MINERAL ECONOMICS (MN EC)

JOHN D. RIDGE, *Head of the Department*
104 Mineral Sciences Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Gordon, Harris, Ridge, and Schneck.
Graduate Faculty: Associate Member Tilton.

The program in mineral economics prepares students for careers in mineral industries management, administration, or economic analysis and planning. Students may specialize in such areas

as commodity analysis (fuels, metals, or nonmetals); resource economics (mineral policy or area studies); industrial economics (administration, market research, or financial matters); geostatistical and economic analysis of exploration and exploitation problems; or operations research and statistics (resource allocation, forecasting, or decision making).

Two related but distinctly different general programs for obtaining the M.S. and Ph.D. degrees are available, the one chosen depending on the education and practical experience of the candidate. One program is for students whose background is in the mineral industries and who wish to combine their scientific training with an understanding in depth of the methods by which economics can aid in solving problems in mineral industries exploration, exploitation, and processing. Requirements for admission to this program are 24 credits in chemistry, physics, mathematics, or statistics; 12 in the earth sciences; 9 in economics, mineral economics, commerce, business administration, or industrial management; and 6 in engineering subjects.

The second program is for students whose background is in economics and whose training and experience have given them an interest in applying their economic skills to the solution of mineral industries problems. Requirements for admission to this program are 12 credits in economics, mineral economics, and business administration; 6 in geological sciences; and 9 in mathematics and statistics.

The differences between the programs followed by these two groups of students will affect every aspect of their graduate programs — thesis work, required mineral economics courses, and elective selection. In all cases, the choices among courses and the emphasis within courses taken would be determined by the background of the student, the mineral industries-based program placing equal weight on the technical and economic aspects of mineral economics and the economics-based program placing more weight on the economic than on the technical features of the problems considered.

In addition to the normal degree requirements of the Graduate School, candidates for the M.S. degree must write a thesis and defend it orally. Doctoral candidates in the mineral industries-based program must complete at least 15 credits in economics (including courses used for admission). Doctoral candidates in the economics-based program must complete at least 12 credits in the earth sciences or mineral engineering. The candidacy examination for the doctorate is entirely written, with the exception that the oral examination for the M.S. degree at The Pennsylvania State University may be used as the candidacy examination for the doctorate. If this is done, the M.S. examination will be more detailed and broader in scope than it would be for the M.S. alone. The comprehensive examination for the doctorate includes written examinations in the major program and minor fields in addition to the oral examination required by the Graduate School. The communication and foreign language requirement for the Ph.D. degree may be satisfied by competence (as defined by departmental rules) in one foreign language or mathematical statistics.

Students with deficiencies of 9 credits or fewer in either program may be admitted as degree candidates but will be required to make up such deficiencies without these credits being applicable toward the advanced degree. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

MINERAL ECONOMICS (MN EC)

400. Seminar (1)
453. Nonmetallic Minerals (3)
483. Economics of the Metals Industries (3)
484. Political Economy of Energy and the Environment (3)
486. The Energy Market (3)
490. Mineral Valuation (3)
491. Analysis of Mineral Data (3)
496. Mineral Industries Decision Making (3)

500. Advanced Readings in Mineral Economics (3) Selected readings on topics in mineral history, mineral economics research, applications of economic theory, mineral policy and law, and mineral exploration.

504. ADVANCED PRINCIPLES OF MINERAL ECONOMICS (3) Minerals as capital — taxation, conservation, and land tenure; operations of mineral markets; government policy; minerals in world trade and development.

506. ADVANCED STUDIES IN MINERAL COMMODITIES (3) Economic studies of selected mineral commodities and their products. Prerequisite: Mn.Ec. 491.

513. APPRAISAL OF MINERAL RESOURCES AND ANALYSIS OF EXPLORATION DECISIONS (3) Mineral resource concepts; various quantitative methods for resource evaluation, including computer simulation; exploration economics and decision making within quantitative frameworks. Prerequisites: Mn.Ec. 490, 491.

593. TECHNICAL PROBLEMS IN MINERAL ECONOMICS (1-12) Individual research involving library, laboratory, or field work designed to provide solutions to a selected technoeconomic problem in mineral industries. Prerequisites: Mn.Ec. 500, 504.

MINERAL ENGINEERING MANAGEMENT (M E M)

THOMAS V. FALKIE, *Chairman of the Committee on Mineral Engineering Management*
118 Mineral Industries Building

Degree Conferred: M.Eng.

Graduate Faculty: Senior Members Aplan, Charmbury, Essenhigh, Falkie, Farouq Ali, Given, Griffiths, Harris, Healy, Hummel, Lovell, W. Miller, Niebel, Ridge, Rosenshine, Schenck, Slobod, Stahl, Stefanko, and Williamson.
Graduate Faculty: Associate Members Guild, Manula, Saperstein, and Slater.

This program is designed to educate engineers for advancement into executive production management positions in the mineral and heavy construction industries, in development and sales in manufacturing companies, and in consulting firms. Its aim is to provide the knowledge, skills, and attitudes needed by persons to become innovators and responsible decision-making leaders. Participants are trained to create new designs, systems, and methods, and to plan, develop, and lead mineral industry organizations.

The content of appropriate courses is based upon specific problems encountered in the mineral industries. Such courses are offered by the departments which have combined their resources to offer this interdisciplinary effort; namely, Departments of Mineral Engineering (Mining and Petroleum and Natural Gas Sections), Mineral Economics, Material Sciences, and Industrial and Management Systems Engineering. Courses in these areas and others may be selected by students and adapted to their individual interests.

The program emphasizes quantitative methods, principles of economics applied in mineral industries, and management.

Students are required to present a scholarly written report on a suitable project, the topic of which may be suggested by industry.

For admission a bachelor's degree in one of six engineering branches of mineral industry (mining, petroleum, mineral processing, metallurgy, fuel, and ceramics) or some other closely related field (industrial, civil, geological, mechanical, or chemical engineering) is required. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exception to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

MINERAL ENGINEERING MANAGEMENT (M E M)

510. PRODUCTION AND OPERATIONS MANAGEMENT (3-9) Overall planning, design, and selection of equipment; programming and scheduling of mineral operations; statistical control of costs and production indices.

MINERAL PROCESSING (MN PR)

FRANK F. APLAN, *In Charge of Graduate Programs in Mineral Processing*
4 Mineral Sciences Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Aplan, Austin, and Sun.
Graduate Faculty: Associate Member Hogg.

This program is one of the options in which a graduate student in the Department of Material Sciences can receive an advanced degree. The process engineering of minerals involves treatment of raw materials to prepare them for conversion to useful products and is basic to such important industries as steel, coal, nonferrous metals, heavy chemicals, nonmetallic minerals, cement, etc. The mineral processing engineer is concerned with the separation of valuable materials from worthless rock by physical and chemical means as well as with the application of these methods to the recycle processing of used metals and minerals. He is also vitally interested in the control of air, land, and water pollution — particularly as it relates to mineral raw materials.

The training of a mineral processing engineer involves interdisciplinary combinations of chemistry, physics, the geological sciences, and engineering. This knowledge is then integrated with specialized knowledge — the creation, characterization, separation and agglomeration of particles; the surface chemistry of mineral particles; and chemical separations — to provide the basis for developing and understanding the practical means of separation of valuable material from that which is worthless.

Pollution control is an important aspect of mineral processing because of the problems of disposal of quantities of waste produced by the mining, metallurgical, cement, power, and heavy chemical industries; the volume of process water used by heavy industries; the use of mineral processing equipment and processes in most air and water pollution control methods; and the application of mineral processing methods to the recycling and reuse of metals and other valuable materials. Specifically designed courses of study are available to allow the student to emphasize pollution control in his course work and thesis research. In addition, the section is one of those cooperating in the all-University interdisciplinary program leading to the Master of Science in Environmental Pollution Control or the Master of Environmental Pollution Control.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by reading proficiency in one foreign language. Students whose first language is English will demonstrate proficiency in German, Russian, or Japanese (or other language in which a major body of relevant technical literature exists). Where practicable, the examination will be one given or recommended by the language department. Students whose first language is not English will be required to show fluency in reading, speaking, comprehending, and writing English and may be required to demonstrate proficiency in one other language (German, Russian, or Japanese). They will normally be expected to take Spch. 115 and pass it with a grade of B or A (unless the report of the Language Testing Center for International Students indicates that this is unnecessary) and, in addition, practice in writing and discussing papers in English will be required by the study panel until a satisfactory standard is obtained. A seminar presentation is required.

Graduates with bachelor's degrees in ceramics, chemistry, chemical engineering, fuel science, the geological sciences, mathematics, metallurgy, mining, physics, or some branch of engineering are eligible for admission. Students with deficiencies may be required to make them up concurrently with their graduate studies. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

The following courses listed elsewhere are appropriate for Mineral Processing students: Mat.Sc. 411, 420; Metal. 401, 402, 404, 420, 421, 423, 424, 425, 460.

MINERAL PROCESSING (MN PR)

*400. Special Problems (1-9)

501. Interfacial Phenomena in Mineral Systems (3) Applications of surface phenomena to mineral engineering systems. Thermodynamics of surfaces, flotation, adsorption of detergents, electrical double layer, flocculation, dispersion. Prerequisite: Chem. 451. *Staff*

502. Froth Flotation and Agglomeration (3) Intensive study of theory and applications of froth flotation and agglomeration. Prerequisite: Mn.Pr. 501. *Staff*

505. Physical Separations in Mineral Processing (3) Intensive study of theory and applications of gravity, magnetic, electrostatic, centrifugal and other methods of mineral processing. Prerequisite: Metal. 420. *Staff*

506. Mineral Process Plant Design (3-10) Process design and economy. Development and quantification of flow sheets. Integration of unit operations. Plant layout, equipment selection and instrumentation. Prerequisite: Metal. 420. *Staff*

507. Chemical Methods in Mineral Processing (3) Practice and theory of methods to upgrade ores by chemical treatment including roasting, solubility separations, surface phenomena, and reactions. Prerequisite: Metal. 420. *Staff*

508. Mineral Particle Systems (3) Creation, characterization, separation and agglomeration of particles. Comminution, sizing, fractionation of powders; surface area, pore size determinations. Agglomeration and balling. *Staff*

509. Particle-Fluid Dynamics (3) Movement of particles in fluids, rheology of non-Newtonian mineral suspensions, design of concentrating devices, fluidized beds, electrodynamic, magnetic separations. *Staff*

MINERALOGY AND PETROLOGY (MIN P)

ARTHUR L. BOETTCHER, *In Charge of Graduate Programs in Mineralogy and Petrology*
211 Deike Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Barnes, Bates, Boettcher, Burnham, Dachille, Griffiths, Keith, Langmuir, Muan, Newnham, Rose, Roy, Smith, Thornton, White, and Wickman.
Graduate Faculty: Associate Members Deines, Kerrick, Ohmoto, and Suhr.

Areas of specialization include igneous, sedimentary, and metamorphic petrology, experimental petrology, mineralogy, crystallography, crystal chemistry, X-ray mineralogy, clay mineralogy, ore mineralogy, and application of statistics in the earth sciences.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages or by comprehensive knowledge of one.

The general requirements for admission are mathematics through integral calculus; chemistry through quantitative analysis; 10 credits in general physics; and 30 credits in geology, petrology, and mineralogy including microscopical petrography. Additional specific requirements must be fulfilled in most areas of specialization.

Students who have taken somewhat less than the indicated minimum of subjects may be admitted but must make up their deficiencies concurrently with their graduate studies. Students with a 2.70 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.70 grade-point average may be made for students with special backgrounds, abilities, and interests.

The nonthesis option is available for the M.S. degree.

*May be repeated for a total of 9 credits.

MINERALOGY (MIN)

400. (Cer.Sc. 400) NONMETALLIC CRYSTAL CHEMISTRY (2-3)
402. MINERALOGY AND PETROLOGY FOR TEACHERS (3) *Mr. Thornton*
411. (Mat.Sc. 411) INSTRUMENTAL TECHNIQUES APPLIED TO MATERIALS AND MINERAL SCIENCE PROBLEMS (1-5)
Unit A. X-RAY DIFFRACTION
Unit B. ELECTRON MICROSCOPY *Mr. Thrower*
Unit C. SPECTROSCOPY *Mr. Suhr*
Unit D. ELECTRON PROBE ANALYSIS *Mr. E. White*
Unit E. SCANNING ELECTRON MICROSCOPY *Mr. E. White*
421. (Mat.Sc. 421) X-RAY DIFFRACTION (3) *Mr. Smith*
450. VOLCANOLOGY (3) *Mr. Thornton*
463. OPTICAL MINERALOGY (3) *Mr. Kerrick*
483. PETROLOGY (3) *Messrs. Kerrick and Thornton*
484. PETROLOGY AND GEOCHEMISTRY OF SEDIMENTS (3) *Messrs. Langmuir and Williams*
490. PETROGRAPHIC PROBLEMS (1) *Mr. Thornton*

500. OPTICAL CRYSTALLOGRAPHY OF MATERIALS (3) Optical methods, microscopic techniques, and measurement of optical constants of crystals; theory and application of the universal stage. Prerequisite: Min. 463. *Mr. Kerrick*

*510. METAMORPHIC PETROLOGY (2-6) Detailed review of chemical, mineralogical, and structural changes that take place during metamorphism. Prerequisites: Min. 483, 484. *Mr. Kerrick*

513. SCIENTIFIC METHOD IN GEOSCIENCE (3) Problem formulation, sampling designs, selection of variates, and comparison of techniques for analysis of aggregates. *Mr. Griffiths*

514. STATISTICAL AND ELECTRONIC DATA PROCESSING PROCEDURES FOR GEOSCIENCE (3) Statistical analysis of experimental data using univariate and bivariate procedures. *Mr. Griffiths*

515. ORE MICROSCOPY (3) Optical and hardness measurements and phase equilibria as used in identification and interpretation of textures of ore minerals. *Mr. Barnes*

525. IGNEOUS PETROLOGY (2-6) Origin, distribution, and composition of igneous rocks. Prerequisites: Gchem. 513; Min. 483, 484, 500, 527. *Messrs. Burnham and Thornton*

526. PROBLEM SOLVING IN GEOSCIENCE (3) Multivariate statistical analysis, decision making, operations research, and systems analysis in geoscience. *Mr. Griffiths*

527. MINERALOGY I — SILICATES (3) Detailed study of the crystal structures and crystal chemistry of the silicate minerals. *Mr. Smith*

528. MINERALOGY II — NONSILICATES (3) Detailed study of the crystal structures and crystal chemistry of the nonsilicate minerals. *Mr. Smith*

530. (Cer.Sc. 530) STRUCTURE, PROPERTIES, AND OCCURRENCE OF CLAY MINERALS (2-5) Structure analysis and identification of clay minerals; mineral transformations and behavior; occurrence, genesis, and petrography of fine-grained sediments. *Mr. Brindley*

531. (Mat.Sc. 531) TRANSMISSION ELECTRON MICROSCOPY (2) Discussion of electron image contrast theory as a tool for study of atomic substructures in the materials and mineral sciences. Prerequisite: Min. (Mat.Sc.) 411B. *Mr. Thrower*

532. (Mat.Sc. 532) STRUCTURE ANALYSIS (2) Crystal structure determination methods: space groups, structure factors, heavy atoms and isomorphous replacement, Fourier synthesis, Patterson maps, inequalities, refinement techniques. Prerequisite: Mat.Sc. (Min.) 421. *Messrs. Newnham and Smith*

533. (Mat.Sc. 533) SINGLE CRYSTAL METHODS (2) Experimental techniques in crystal structure determination: crystal selection, space group determination, measurement of intensities, analysis of data. Prerequisite: Mat.Sc. 421 or Min. 421. *Mr. Ryba*

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*Credits to be arranged, 2-4 per term.

534. (Mat.Sc. 534) DIFFRACTION BY CRYSTALS (2) Interaction of radiation with matter: coherent and incoherent scattering, extinction, fluorescence, polarization. Prerequisite: Min. (Mat.Sc.) 421. *Mr. McKinstry*

535. (Mat.Sc. 535) GEOMETRICAL CRYSTALLOGRAPHY (3) Derivation of lattices, types, point groups and space groups with applications. *Mr. Smith*

538. (Mat.Sc. 538) ELECTRON BEAM ANALYSIS OF SOLIDS VIA X-RAY AND ELECTRON EMISSION (3) Theory of phenomena occurring in electron-bombarded solids and their applications to analysis of solids. *Mr. E. White*

540. METEORITICS (2) Mineralogy, petrology, and chemistry of meteorites; theories of their origin and formation. Prerequisite: Min. 483 or 501. *Mr. Wickman*

NOTE: *Additional general courses in this field are listed under Geological Sciences.*

MINING ENGINEERING (MNG E)

THOMAS V. FALKIE, *Head of the Department of Mineral Engineering*
118 Mineral Industries Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Charmbury, Falkie, Hardy, Lovell, Stefanko, and Voight.
Graduate Faculty: Associate Members Manula and Saperstein.

Areas of specialization which may be followed in research and course work include mine property valuation and economics of mining engineering (ore estimation, cost analysis and control, budgeting); mechanization and mine plant (unit operations, materials handling, continuous mining, power supply); development and exploitation methods (mine planning and layout, design of systems); mine management, production engineering (work and methods analysis, operations analysis); operations research, environmental control and health and safety (gas and dust technology, ventilation, air conditioning, hygiene, illumination, noise, safety, mine drainage, land reclamation, waste disposal); and rock mechanics (stress analysis, roof and ground control, penetration, fragmentation, subsidence).

Students who desire to obtain the Master of Engineering degree in mining engineering must take a minimum of 30 credits (including at least 12 credits at the 500 level) of appropriate courses in the major area and elective courses. A scholarly written report is also required. Programs of study are available in general mining engineering, rock mechanics, mine operations, research systems engineering, internal or external mine environmental control, mine health and safety; and emphasis can be given to any of the areas listed above.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by completion of courses in two languages or by completion of courses in one language and 6 credits of computer science. A thesis is required for the M.S. degree.

A bachelor's degree in mining engineering or a related engineering field is required for admission. Students may be required to make up deficiencies in their area of specialization. Certain basic related courses outside the department may be approved as part of the major. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

MINING (MNG)

400. MINING AND OUR ENVIRONMENT (3)
402. MINE PLANT DESIGN (3)
410. MINING ENGINEERING ANALYSIS (3)
411. MINE SYSTEMS ENGINEERING (3)
422. MINE VENTILATION AND AIR CONDITIONING (3)

431. Rock Mechanics (3)
451. Advanced Mining Engineering (1-3)

513. Mine Cost Analysis (3) Nature of mining costs, their analysis and control: depreciation and depletion, capital and operating costs, budgets, records.

514. Mine Operations Analysis (3) Application of operations research techniques in determining optimal design and operating policies for mine management. Prerequisite: Mng. 411.

515. Mine Systems Simulation (3) Principles and practices of probabilistic and deterministic simulation in the analysis of operating systems related to mills and mines. Prerequisites: Cmp.Sc. 401, Mng. 411.

531. Rheological and Strength Characteristics of Rocks (3) Properties of rocks and their determination; failure theories; brittle to ductile transition; rheological behavior. Prerequisite: Mng. 431.

532. Special Topics in Rock Mechanics (1-3) Behavior of rock under static loading; underground stress instrumentation; experimental stress analysis; design of mine openings; theories of subsidence.

533. Post-Yield Mechanics of Rock (3) Theory of inelastic, time-independent rock behavior; selected applications to drilling, blasting, mine opening, pit slopes, and ore passes. Prerequisite: Mng. 431.

542. Theory of Rock Fragmentation (3) Behavior of rock under dynamic loads intended to fragment; physical chemistry of explosives; detonation; theory of blasting; design of drill rounds. Prerequisites: E.Mch. 13, Mng. 30, Phys. 203.

543. Strata Control Engineering (3) Theoretical considerations; convergence, abutments, subsidence; rockbursts; underground support systems; design of mine openings. Prerequisite: Mng. 431.

545. Rock Mechanics Instrumentation (3) Strain gage circuitry, transducers, electrohydraulic servo installations, and integrated strain and force measuring systems as applied to rock mechanics. Prerequisite: Mng. 431.

580. Mining Engineering Research (1-3 per term) Supervised research on a specific problem involved in mining science or technology.

MUSIC (MUSIC)

Robert W. Baisley, *Head of the Department*
232 Music Building

Degrees Conferred: M.A., M.F.A.

Graduate Faculty: Senior Members Baisley and Brinsmaid.
Graduate Faculty: Associate Members Brown, J. Feldman, L. Feldman, Fenner, and Miller.

The Master of Arts degree program is designed to provide a wide range of studies in music. The student may emphasize one of the following areas, or may elect a program including work in all of them: theory, performance, history, and composition. Admission requires completion of a recognized music major. A thesis or paper is optional to all M.A. candidates in the program.

The Master of Fine Arts degree program is planned to provide professional emphasis. Students will specialize in either performance or composition. In addition to credit requirements, admission to the program is contingent upon department certification of the candidate's competence. According to the area of specialization, auditions or submission of manuscripts are required. Arrangements for this can be made by the student with the department. While 48 credits are listed as a minimum requirement, it should be noted that the amount of course work necessary may exceed the minimum according to the needs and background of the student involved.

Students who lack the recommended upper-class courses in music may be required to take additional course work without receiving graduate credit.

The department sponsors musical activities, and candidates for both degrees are required to participate in positions of responsibility.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

MUSIC (MUSIC)

410. Music of the Twentieth Century (3)
412. Music of the Baroque Period (3)
413. Music of the Middle Ages (3)
414. Music of the Renaissance (3)
417. Music of the Classical Period (3)
418. Music of the Romantic Period (3)
*429. Vocal Style (3) Fee $80.
433. The Singing Voice (3)
455. Form and Analysis (2)
457. Composition (2)
459. Orchestration and Arranging (3)
465. Form and Analysis (2)
466. Advanced Conducting (2)
467. Opera Workshop (1-6)
468. Advanced Chamber Music (1-6)

*501. Advanced Harpsichord (3) Instruction in harpsichord playing; preparation for recital performance. Fee $100.

*503. Advanced Orchestral Instruments (3) Study, repertoire building, and recital performance. Fee $80.

*511. Advanced Piano (3) Piano literature of all periods for public performance. Fee $80.

*520. Voice (3) Study, repertoire building, and recital performance. Fee $80.

*531. Advanced Organ (3) Study, repertoire building, and recital performance. Prerequisite: 4 credits of Music 31 and/or 38. Fee $100.

543. Modern Harmony (3) Harmonic writing based on twentieth century practices with attention to traditional idioms that serve as foundation.

545. Counterpoint (3) Principals of contrapuntal techniques from the sixteenth century to the present. Required of all M.F.A. candidates in composition.

*558. Free Composition (3) Composition: vocal and instrumental, standard or modern idioms.

+560. Orchestral and Choral Conducting (3) Supervised conducting in selected performance situations, rehearsal techniques and comprehensive score analysis.

571. Performance Practices (3) Analysis and performance of music of various periods based on manuscripts, documents, and other source materials.

580. Studies in Orchestral Literature (3) Selected studies in orchestral literature from the seventeenth century to the present.

581. Studies in Chamber Music Literature (3) Selected studies in chamber music of all types from the seventeenth century to the present.

582. Studies in Keyboard Literature (3) The literature of major keyboard instruments from the sixteenth century to the present.

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*Course may be scheduled only by conference with the head of the department. May be repeated for a total of 18 credits.

+ May be repeated for a total of 9 credits.

583. STUDIES IN CHORAL LITERATURE (3) Selected studies in choral literature of all types from the Renaissance to the present.

584. STUDIES IN OPERATIC LITERATURE (3) Studies in the development of the opera from 1600 to the present treating both libretto and music.

589. MUSIC SEMINAR (1-6) Seminar in the history, art, and science of music, with readings, discussion, and performance.

MUSIC EDUCATION (MU ED)

FRANCES M. ANDREWS, *Head of the Department*
264 Chambers Building

Degrees Conferred: D.Ed., M.Ed.

Graduate Faculty: Senior Members Andrews, Campbell, Deihl, and Dunlop.
Graduate Faculty: Associate Member Boyle.

Graduate programs in music education prepare students for careers in public school music teaching, music supervision, college teaching, administration, or research. It is possible to include study in a number of these areas in the M.Ed. or D.Ed. programs.

Completion of a recognized music education major, or program leading to teaching certification in music, is a prerequisite for admission to the M.Ed. or D.Ed. programs.

Applicants for the master's program who present a 2.50 junior-senior average and two satisfactory professional references will be considered for admission to the Department of Music Education, provided they have appropriate course backgrounds and musical proficiency.

Admission to the doctoral program requires: a junior-senior minimum average of "B"; approximately half of any graduate credits of "A" quality; interview prior to admission; submission of satisfactory score on Miller Analogies Tests; five recommendations attesting to scholarship, musicianship, and ability to do independent study; and a minimum of two years of successful teaching experience in public or private schools.

The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum grade-point average may be made for students with special backgrounds, abilities, and interests.

MUSIC EDUCATION (MU ED)

415. WORKSHOP IN SELECTED MUSIC EDUCATION STUDIES (1-6)
445. METHODS, ELEMENTARY GRADES (3)
446. THE ELEMENTARY MUSIC SPECIALIST (3)
448. METHODS, JUNIOR AND SENIOR HIGH SCHOOLS (3)
449. STUDENT TEACHING IN THE ELEMENTARY SCHOOL (2-6)
450. STUDENT TEACHING IN THE HIGH SCHOOL (2-6)
454. ORCHESTRA AND BAND METHODS AND MATERIALS (3)
455. STUDENT TEACHING IN INSTRUMENTAL MUSIC (2-6)
468. THE TEACHING OF PIANO (3)
469. BAND AND ORCHESTRA TECHNIQUE (3)
471. TEACHING MARCHING BAND (3)
472. WIND INSTRUMENT MATERIALS (3)
473. PSYCHOLOGICAL FOUNDATIONS OF MUSICAL BEHAVIOR (3)
474. TESTS AND MEASUREMENTS IN MUSIC (3)
480. CHORAL PROGRAM IN THE SECONDARY SCHOOL (3)
487. CHILDREN'S SONGS AND RECORDS (3)

500. MUSIC EDUCATION SEMINAR (3-6) Problems of various phases of music education, both instrumental and vocal; research and literature dealing with these problems.

501. PROBLEMS AND PROJECTS IN MUSIC EDUCATION (1-6) Independent work on special topics of music education pertinent to the development of curricula, methods, and materials in music education. Prerequisite: 12 graduate credits in education (including music education).

525. PROSEMINAR: GRADUATE STUDY IN MUSIC EDUCATION (1-3) Bibliography; location and evaluation of reference materials; organization, form, style in preparing music education research reports and other papers.

555. RESEARCH METHODS IN MUSIC EDUCATION (3-6) Research methods and designs for problems in music education; techniques for studying cognitive, affective, and psychomotor responses to musical stimuli. Prerequisites: Mu.Ed. 525, Ed.Psy. 406 or 407, 475.

569. PRESENT-DAY TRENDS IN INSTRUMENTAL MUSIC (3-6) New methods and materials for band, orchestra, and ensembles.

570. CHORAL TECHNIQUE (3-6) Analysis and evaluation of choral materials appropriate for secondary school chorus; program building; practical rehearsal and conducting techniques. Prerequisite: 6 credits of vocal study.

572. INSTRUMENTAL PEDAGOGY (3-6) Research problems in band and orchestra. Prerequisite: Mu.Ed. 54 or practical experience.

573. THE MATERIALS OF APPRECIATION (3) Examination of written and recorded materials and appropriate techniques for developing appreciation of music, grades one through twelve.

574. PRESENT-DAY TRENDS IN MUSIC EDUCATION (3-6) Present-day music education materials and methods (elementary and secondary levels) in relation to modern educational philosophy; emphasis on practical problems presented by members of the class. Prerequisites: Mu.Ed. 48, teaching experience.

575. THE JUNIOR HIGH SCHOOL MUSIC CURRICULUM (3) Instructional materials, procedures, curricular and extracurricular activities, integration with other subjects.

576. MUSIC SUPERVISION (3) Current educational procedures in training music supervisors.

581. CONTEMPORARY MUSIC EDUCATION (3) Prerequisite: 20 credits at the graduate level including Mu.Ed. 500.

582. THEORY AND PROJECTS IN MUSICAL LEARNING (3-6) Experimentation and self-instructional techniques involved in musical learning projects. Prerequisite: Inst.M. 435.

591. INTERNSHIP IN MUSIC PERFORMANCE TECHNIQUES (1-6) Internship in selected school or music performance situations other than those in the district where the graduate student is employed.

594. PEDAGOGY OF MUSIC THEORY, READING, AND EAR TRAINING (3) Instructional theory and materials basic to teaching music theory, reading, and ear training. Musical instruments, audio-visual devices as aids. Prerequisite: 12 credits in music theory and/or harmony.

NUCLEAR ENGINEERING (NUC E)

WARREN F. WITZIG, *Head of the Department*
231 Sackett Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Diethorn, Foderaro, Jacobs, Kenney, Klevans, Levine, Palladino, Remick, Schultz, and Witzig.
Graduate Faculty: Associate Members Jester and Robinson.

Programs of study are individually tailored, and engineering is emphasized through the study of reactor principles — computational methods, transport theory, and nuclear design; plasma principles — waves, analysis, and fusion laboratory; shielding — Monte Carlo methods and two-body kinematics; reactor systems design — thermal, mechanical, and control; reactor fuels — configuration, radiation effects, and fuel cycle management; isotope utilization — activation analysis, chemical processes including copolymerization and nuclear medicine; plowshare ap-

plications; safety analysis — reactor siting, engineered safeguards, and environmental effects. The department offers three degrees at the master's level: M.Eng., M.S. with paper, and M.S. with thesis. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language and proficiency in English.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

NUCLEAR ENGINEERING (NUC E)

400. Nuclear Engineering Special Topics (1-12)
401. Introduction to Nuclear Engineering (3)
402. Introductory Reactor Analysis II (3)
410-411. Nuclear Reactor Theory (3 each)
415. Radionuclear Applications (3)
420. Radiological Safety (3)
425. (Biol.E. 425) Radiographic Imaging (3)
428. Radioactive Waste Control (3)
430. Design Principles of Reactor Systems (3)
431. Synthesis of Nuclear Systems (3)
440-441. Nuclear Engineering Laboratory (3 each)
490. (E.E. 490) Introduction to Plasmas (3)

501. Reactor Engineering (3) Reactor controls, shielding of nuclear reactors, stress analysis of reactor materials, power cycle analysis, breeding, and advanced design considerations. Prerequisite or concurrent: Nuc.E. 411.

502. Reactor Engineering Laboratory (1-5) Reactor experiments devised to acquaint the student with reactor technology. Prerequisite or concurrent: Nuc.E. 411.

503. Thermonuclear Engineering (3) Binary fusion reactions; microscopic and macroscopic phenomena in a completely ionized gas; electromagnetic confinement; design, operation, and diagnostics of experiments. Prerequisite: Math 452.

505. Reactor Instrumentation and Control (3) Neutron-detecting instruments and circuits; in-core power instrumentation; reactor control principles; control mechanisms; operational control problems. Prerequisite: Nuc.E. 411.

506. Two-Body Kinematics (3) Conservation laws of classical and quantum mechanics and their application to interactions between two bodies. Prerequisite: Math. 72.

507. Interaction of Radiations with Matter (3) Theory of the processes by which gamma rays, neutrons, and charged particles interact with electrons, atoms, and nuclei. Prerequisite: Nuc.E. 506.

509. Radiation Damage in Solids (2) Production of defects by high energy particles; nature of defects; diffusion and annealing in solids; macro property changes. Prerequisite: Nuc.E. 507.

511. Nuclear Reactor Materials (3) Philosophy, selection, technology, use, economics, and performance of materials of major interest in nuclear power reactors today. Prerequisite: Nuc.E. 411.

520. Reactor Analysis (3) Physical principles and mathematical methods of reactor analysis. Prerequisite: Nuc.E. 410.

521-522. Neutron Transport Theory (3 each) Derivation of Boltzmann equation for neutron transport; techniques of approximate and exact solution for the monoenergetic and spectrum regenerating cases. Prerequisite: Nuc.E. 410 or Phys. 406.

540. (E.E. 540) Theory of Plasma Waves (3) Solutions of the Boltzmann equation; waves in bounded and unbounded plasmas; radiation and scattering from plasmas. Prerequisite: Nuc.E. 490.

541. (E.E. 541) Plasma Theory (3) Advanced topics in kinetic theory, fluctuation theory, microinstability, and turbulence. Prerequisite: Nuc.E. (E.E.) 540.

NURSING (NURS)

Laurie M. Gunter, *Head of the Department*
15 Human Development Building

Degrees Conferred: M.N., M.S.

Graduate Faculty: Senior Members Brantl and Gunter.
Graduate Faculty: Associate Members Pierce, Quiring, Sedgwick, and Williamson.

The department recognizes the need for two types of advanced degrees in nursing — academic and professional. The Master of Science degree is offered in recognition of the completion of programs which emphasize productive scholarship and research and preparation for teaching or administration. The Master of Nursing degree is offered in recognition of the completion of programs which emphasize the practical application of science to the solution of nursing and health care problems and preparation as a specialized nurse clinician.

The student may select one of the following emphases in nursing: 1) health care, 2) acute or intensive care nursing. 3) long-term care. Options within these emphases for clinical specialization in nursing will be offered in such areas as family health nursing, community health nursing, school health nursing, geriatric nursing, and psychiatric nursing.

For the Master of Science degree, each student must have a minimum of 40 graduate credits with at least 30 earned on the University Park Campus. Included in these requirements are a minimum of 3 credits in nursing practicum, 6 credits to support the career goal of administration or teaching, and 10 credits in thesis and methods of research. Each student is required to complete a thesis and successfully pass a comprehensive examination.

For the Master of Nursing degree, a minimum of 30 graduate credits is required with at least 20 to be earned on the University Park Campus. At least 10 of these credits must be earned in nursing practicum courses. Each student must present an acceptable clinical paper and successfully pass a comprehensive examination.

Applicants should hold a baccalaureate degree in nursing from an NLN accredited program or its equivalent. (Students with degrees from non-NLN accredited programs will be evaluated by the Admissions Committee in the department on an individual basis.) Students judged to have deficiencies may be eligible for admission with the understanding that all deficiencies must be completed. An overall grade-point average of 2.50 on a 4-point scale is expected for undergraduate work.

NURSING (NURS)

405. Occupational Health Nursing (3)
410. Nursing Care of the Family in the Community (3)
425. School Health Nursing (3)
445. Trauma Nursing (3)
450. Rehabilitation Nursing (3)
455. Advanced Medical Nursing (3)
460. Advanced Surgical Nursing (3)
490a,b,c,d,e,f,g. Nursing Study in Specialized Setting (1-12)

501. Issues in Nursing and Health Care (2) Consideration of personal, social, political, economic, philosophical, ethical problems/questions and ways of confronting, and resolving conflicts in professional practice.

NUTRITION (NUTR)

HELEN A. GUTHRIE, *In Charge of Graduate Programs in Nutrition*
202 Human Development Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed., M.S. in Nutrition in Public Health

Graduate Faculty: Senior Members Guthrie, Pike, and Underwood.
Graduate Faculty: Associate Members Brinkman, Hathcock, Shannon, Teitelbaum, and Wright.

Graduate programs in nutrition prepare students for careers in college teaching, research, industry, and government. The program in nutrition in public health prepares the student for work in public health agencies and community nutrition.

To satisfy the communication and foreign language requirement for the Ph.D. degree students are expected to demonstrate competence in technical writing (Engl. 418) and spoken English.

For admission to a graduate program in nutrition, a student must have completed at least 6 credits in inorganic and organic chemistry, 3 each in biochemistry, microbiology, and human physiology, 4 in other physical and biological sciences, and 8 in foods and/or nutrition. For admission to the program in nutrition in public health, an additional 12 credits in social sciences are required.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Students with up to 9 credits of deficiency may also be admitted. Any deficiencies must be completed with a grade of B within two terms.

NUTRITION (NUTR)

400. SPECIAL PROBLEMS IN FOODS AND NUTRITION (1-3)
420. EXPERIMENTAL COOKERY (3)
421. CULTURAL AND AESTHETIC ASPECTS OF FOOD (3)
422. SCIENTIFIC PRINCIPLES OF FOOD PREPARATION (3)
452. NUTRITIONAL ASPECTS OF DISEASE (3)
453. DIET THERAPY (2)
456. NUTRITION IN THE COMMUNITY (3)
457. PRINCIPLES OF NUTRITION (3)
458. APPLIED NUTRITION (2)
459. ADVANCED NUTRITION (3)
490. FOODS AND NUTRITION SEMINAR (1)

520. READINGS IN APPLIED NUTRITION (2) Critical review and reports of literature on selected topics in applied nutrition.

521. TOPICS IN NUTRITION (1-6) Intensive study of current developments on selected topics in nutrition.

522. ADVANCED EXPERIMENTAL FOODS (3) Experimental methods used in measuring the quality of foods; specific problems in food preparation.

530. PROBLEMS IN FOODS AND NUTRITION (1-6)

550. READINGS IN NUTRITION (3) Readings and reports of selected topics in nutrition.

551. SEMINAR IN NUTRITION (1-6) Selected topics and recent advances in nutrition.

552. NUTRITION IN DISEASE (3) Physiological and biochemical problems in metabolic diseases and the nutritional aspects of therapy.

555. FIELD WORK IN NUTRITION (2-4) Field problems planned to meet the needs of individual students. Hours and problems to be arranged.

556. THE SURVEY METHOD IN FOODS AND NUTRITION (2) Study of survey techniques as a tool in the assay of food adequacy and nutritional status.

557. INTERRELATIONSHIPS OF NUTRIENTS (2) Interrelationships of nutrients in the metabolic processes; their significance as applied to nutrition.

PETROLEUM AND NATURAL GAS ENGINEERING (PNG E)

C. DREW STAHL, *Head of the Section of Petroleum and Natural Gas*
25 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Burcik, Farouq Ali, Slobod, and Stahl.
Graduate Faculty: Associate Member Slater.

Areas of specialization include experimental and theoretical studies of water flooding and the newer methods for displacing oil from porous media, methods for calculating reservoir performance, scaled laboratory studies of reservoir phenomena, and drilling and well completion problems.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Students who expect to enter graduate study in this program with a degree in another major should present 6 credits in geology, 15 in engineering science, and credit for mathematics through integral calculus. A limited number of deficiencies may be made up after admission. Certain closely related courses outside the department may be counted as petroleum and natural gas credits toward the degree.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

PETROLEUM AND NATURAL GAS (P N G)

400. THESIS (1-6)
410. APPLIED RESERVOIR ENGINEERING (3)
420. APPLIED RESERVOIR ANALYSIS (3)
421. RESERVOIR ENGINEERING (3)
430. RESERVOIR MODELING (3)
440. FORMATION EVALUATION (3)
450. DRILLING DESIGN AND PRODUCTION ENGINEERING (3)
475. PETROLEUM ENGINEERING DESIGN (3)
480. PRODUCTION PROCESS ENGINEERING (3)
481. NATURAL GAS AND GASOLINE PLANTS (2)
485. ENGINEERING IN SECONDARY RECOVERY (3)
493. ENGINEERING EVALUATION OF OIL AND GAS PROPERTIES (3)

510. SOLUTION OF THE PARTIAL DIFFERENTIAL EQUATIONS OF FLOW IN POROUS MEDIA (3) The application of mathematical techniques to solve the partial differential equations of steady and unsteady state flow in porous media. Prerequisite: Math. 405.

511. NUMERICAL SOLUTION OF THE PARTIAL DIFFERENTIAL EQUATIONS OF FLOW IN POROUS MEDIA (3) Differencing schemes for the partial differential equations of single-phase flow; application to flow of gas and mixing in porous media.

512. NUMERICAL RESERVOIR SIMULATION (3-6) Mathematical analysis of complex reservoir behavior and combination drives; numerical methods for the solution of behavior equations; recent developments. Prerequisite: P.N.G. 510.

514. OPTIMIZATION OF PETROLEUM RECOVERY PROCESSES (3) Optimum search methods, linear programming, nonlinear programming, dynamic programming, application to waterflood-

ing, depletion drive, steam injection, gas cycling, miscible displacement. Prerequisite: P.N.G. 410.

515. ADVANCED OIL RECOVERY TECHNIQUES (3) Advanced oil recovery techniques including water-flooding, in-situ combustion, steam injection, hot-water injection, and miscible-phase displacement.

519. DESIGN OF THERMAL RECOVERY PROJECTS (3) Suitability of reservoirs for thermal oil recovery; case histories; design of in-situ combustion and steamfloods; thermal stimulation; shale oil recovery. Prerequisite: P.N.G. 515.

520. PHASE RELATIONS IN RESERVOIR ENGINEERING (3) Phase relations as applied to condensate and retrograde condensate reservoirs and to other problems in petroleum production.

530. NATURAL GAS ENGINEERING (1-3) Flow in producing or storage reservoirs; gas well testing; transmission systems; storage cycle; current developments. Prerequisite: P.N.G. 481.

NOTE: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in petroleum and natural gas studies are listed under Materials Science.*

PHARMACOLOGY (PHARM)

ELLIOT S. VESELL, *Chairman of the Department*
The Milton S. Hershey Medical Center

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Fritz, Greene, and Vesell.
Graduate Faculty: Associate Members Connor, Hill, Passananti, A. Severs, W. Severs, and Smith.

The department offers opportunities for research and courses in drug metabolism, endocrine pharmacology, neuropharmacology, cardiovascular pharmacology, clinical pharmacology, and general pharmacology. Emphasis is placed on molecular and physiological mechanisms by which drugs act in the body and by which the body transforms drugs.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign languages.

A bachelor's degree reflecting a reasonable background in zoology or biology, mathematics, and chemistry is required; reading knowledge of one or two foreign languages is recommended, but not required. Applicants must provide complete transcripts and two letters of recommendation. Scores from the Graduate Record Examination and a personal interview are desirable. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

This program is offered only at The Milton S. Hershey Medical Center.

PHARMACOLOGY (PHARM)

501. PHARMACOLOGY (3) Lectures, discussions, and laboratory study of the mechanism of drug action in biological systems.

502. PHARMACOLOGY (4) Continuation of Pharm. 501.

504. DRUG METABOLISM (3) Study of chemical transformation of drugs within animal cells and drug-metabolizing enzymes present in liver microsomes performing this function. Prerequisite: Pharm. 501.

506. PHARMACOLOGY OF ENDOCRINE ORGANS (3) Current concepts of interaction of endocrine tissue with endogenous compounds and pharmacological agents. Prerequisite: Pharm. 501.

507. PHARMACOLOGY OF PSYCHOACTIVE DRUGS (3) Current theories of mental diseases and pharmacological agents used to treat them will be covered. Prerequisite: Pharm. 501.

508. Pharmacology of Biologically Active Monamines (3) The role of monamines in body function in alteration of their activity by drugs will be discussed. Prerequisite: Pharm. 501.

509. Development of Therapeutic Agents (3) This course will deal with stages of drug development ranging from laboratory studies to routine human consumption.

512. Clinical Pharmacology (3) Drug therapy of cardiovascular, renal, and neural diseases will be discussed.

515. Human Genetics (2) Seminar-type presentations by students and staff on fundamental problems and current topics in human genetics.

520. Principles of Drug Action (3) Detailed analysis of basic parameters governing drug actions.

530. Pharmacology of Psychotropic Drugs (2) Systematic analysis of the effects of psychotropic drugs.

540. Pharmacogenetics (3) Study of human responses to individual drugs.

550. Autonomic Nervous System Pharmacology (3) Study of drugs concerned with and acting on the sympathetic and parasympathetic nervous systems.

560. Pharmacology Seminar (1-3 per term) Student and staff seminar designed to familiarize medical and graduate students with current research developments in the field.

570. Special Topics (1-6) Introduction of students to the research laboratory and the scholarly pursuits of members of the staff.

590. Research (1-12) Individualized research conducted by students in departmental laboratories.

PHILOSOPHY (PHIL)

CARL R. HAUSMAN, *Head of the Department*
247 Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty: Senior Members Anderson, Ford, Gotshalk, Hausman, Johnstone, Kockelmans, Lingis, and Rosen.
Graduate Faculty: Associate Members Flay, Goldman, Kennington, Price, Tsugawa, Vaught, and Verene.

A thorough grounding in the history of philosophy is desirable for all students. Specialization is possible in areas (such as aesthetics, metaphysics, ethics, social philosophy, logic, and history and philosophy of science); in movements of thought (such as rationalism, empiricism, idealism, phenomenology, and existentialism); or in any of the major figures in the history of western philosophy. Specialization is also possible in a joint program with the Department of Mathematics in logic and the foundations of mathematics and with the Department of Physics in philosophy of science. Undergraduate preparation to the extent of a strong minor is advisable. The department may waive the requirement of a thesis for an M.A. candidate.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages or by comprehensive knowledge of one.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

PHILOSOPHY (PHIL)

406. Medieval Philosophy (3)
408. Studies in Social and Political Philosophy (3)
410. Studies in Greek Philosophy (3-6)

411. Studies in Modern Philosophy (3-6)
412. Studies in Contemporary Philosophy (3-6)
413. Philosophy of Literature (3)
414. Aesthetic Theory (3)
417. Nineteenth Century Philosophy (3-6)
419. Philosophical Backgrounds of American Thought (3)
420. Philosophy of History (3)
421. Classics of Scientific Methods (3)
424. Studies in Philosophy of Religion (3)
426. Metaphysics (3-6)
427. Advanced Ethics (3)
428. (Math. 428) Logical Theory (3)
429. Semantics: Philosophy of Language and Symbolism (3)
430. Philosophical Problems (1-9)
435. (S.T.S. 435) The Interrelation of Science, Philosophy, and Religion (3)

500. Ethics: Historical and Systematic (2-6) Critical study of some phase of ethical theory, or of some period of the history of ethics.

504. Social and Political Philosophy (3-6) Critical study of basic problems in their historical and functional setting.

505. Philosophy of Western Religion (3-6) The consideration of contemporary western religious concepts in terms of their Graeco-Judean traditions.

506. Seminar in Ancient Philosophy (3-6) Study of one or more important men or movements in ancient philosophy.

508. Seminar in Modern Philosophy (3-6) Men and movements in philosophy from the Renaissance through the nineteenth century.

509. Seminar in Contemporary Philosophy (3-6) Men and movements in twentieth century philosophy.

512. Advanced Topics in Philosophy of Science (3-6) Crucial problems in the theory of science and scientific method.

513. (Psy. 513) Principles and Methods of Empirical Science (3) Scientific methodologies and their presuppositions, with special emphasis on behavioral and social sciences.

514. Seminar in Nineteenth Century Philosophy (3-6) Study of a philosopher or philosophical movement of the nineteenth century.

515. Philosophical Method (3-6) Methods proposed by classical and contemporary thinkers for reaching philosophical conclusions: deductive, inductive, dialectical, pragmatic, intuitive.

516. Seminar in Aesthetics (3-6) Problems and theories in the nature of art.

526. Seminar in Metaphysics (3-6) Formulation and analysis of metaphysical problems in the various fields of philosophy.

530. Philosophy Research Seminar (1-12) Study of selected philosophical problems with an emphasis on techniques of philosophical research.

550. (Math. 550) Foundations of Mathematical Logic (3) The nature of logical basis of mathematics; critical examination and development of the basic parts of logical calculus. Prerequisite: Math. 480 or Phil. 428.

554. (Math. 554) Logic and Metamathematics I (3) Completeness, Löwenheim-Skolem, Herbrand, and compactness theorems; first-order theories; categoricity, elimination of descriptions, decidability; algebraic and geometric applications. Prerequisite: Phil. 428.

556. (Math. 556) Recursion Theory (3) Recursive functions; normal form, enumeration and separation theorems; partial recursive functions; recursion theorems; special recursive functions; alternate formulations; related topics. Prerequisite: Phil. 428.

557. (Math. 557) Logic and Metamathematics II (3) Arithmetization; Gödel and Tarski incompleteness theorems; undecidability results; Gentzen-type systems and consistency results. Prerequisite: Phil. 428.

PHYSICAL EDUCATION (PH ED)

Betty van der Smissen, *Associate Dean for Graduate Study and Research*
275 Recreation Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Buskirk, Gross, Harnett, Hunt, Lucas, Mendez, Nelson, Rhoades, and van der Smissen.
Graduate Faculty: Associate Members Gahagen, Harris, Kollias, Lundegren, Magnusson, Morehouse, Nicholas, and Stoedefalke.

Areas of specialization include (1) adapted physical education; (2) administration-supervision (methods and materials, curriculum construction, intramurals, and interscholastics); (3) biomechanics (applied anatomy and kinesiology); (4) health education; (5) history of sport and physical education; (6) measurement and test construction; (7) motor learning; (8) physiology of exercise (physical conditioning, physical fitness, and performance stress); (9) psychosocial foundations of physical activity; and (10) recreation and parks.

Admission to the M.S. program requires a major in physical education or its equivalent in comparable course work. Especially desirable is a concentration on the physical, biological, behavioral, or social sciences, depending upon the intended areas of specialization. Admission to the M.Ed. program requires a minimum of 18 credits in health and physical education plus 18 credits in education and educational psychology combined, including practice teaching. A year or more of field experience is recommended.

Admission to doctoral study requires the master's degree or its equivalent, demonstrated research ability in the form of a thesis or published research, and acceptable performance on the Aptitude Test of the Graduate Record Examination or other specified tests. A student who has earned a master's degree in recreation and parks and meets the above requirements may enter a doctoral program in physical education with specialization in recreation and parks. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests.

See also Recreation and Parks.

HEALTH EDUCATION (HL ED)

411. Principles and Methods of Teaching Safety Education (3)
456. Advanced Techniques in School Community Health Education (3)
496. Special Projects (1-6)

511. (Anthy. 511) Health Implications in the Growth and Development of School Children (3) Child growth and development emphasis for teachers; medical inspection and examination; preschool program; early habit formations; behavior problems; cooperation of parents, teachers, and children. Prerequisite: Hl.Ed. 215.

513. (Anthy. 513) Health Implications in Maturity and Aging (3) Changes in the human body in maturity and aging. Theories and mechanisms of physiologic aging with implications for health education. Prerequisite: Hl.Ed. 501.

PHYSICAL EDUCATION (PH ED)

400. Adapted Physical Education (3)
402. Physical Education for Children with Learning Problems (2)
420. Psychosocial Dimensions of Physical Activity (3)
450. Current Research Literature in Physical Education (3)
452. Analysis of Physical Education Activities for the Elementary School (3)
455. Statistical Methods in Health, Physical Education, and Recreation (3)
456. Physical Fitness Appraisal (3)
460. Methods and Principles of Athletic Coaching (3)
462. Administration of Athletic Programs (2)
470. History and Theory of Dance in Education (2)
480. Exercise Physiology (3)
483. Motor Patterns of Children (3)
484. Kinesiology (3)
489. Intramural Athletics (3)
490. Introduction to Tests and Measurements in Health and Physical Education (3)
491. Organization and Administration of Health and Physical Education in Schools (3)
495. History of Sport in American Society (3)
496. Special Projects (1-6)
497. Sport in Antiquity (3)

500. (Rc.Pk. 500) Individual Study and Research Projects (1-10) Prerequisite: Ph.Ed. 530.

520. Psychology of Sport (3) Study of man's psychological behavior in sport and physical activity; development of somatopsychic theory of physical activity. Prerequisite: 6 credits in psychology.

522. Sport in Society (3) Examination of the cultural phenomenon of sport; social behavior in sport; institution of sport and relationship with other social institutions. Prerequisite: 3 credits in sociology.

530. (Rc.Pk. 530) Research Techniques in Health and Physical Education and Recreation (3)

531. Research in Health and Physical Education and Recreation (3) Prerequisite: Ph.Ed. 530.

532. Tests and Measurements in Physical Education (3) Critical study of tests and measurements available in physical education; methods of contructing and evaluating new tests and measurements. Prerequisite: Ph.Ed. 490.

534. Studies in Curriculum Construction in Physical Education (3) Principles and methods of curriculum building in physical education; different psychological and educational points of view, organizing a course of study committee, making units of instruction.

535. Modern Foreign Systems of Sport and Physical Education (3) Comparative analysis of national and local programs and systems of physical education in foreign countries. Prerequisites: Ph.Ed. 534, 595.

550. Seminar in Health and Physical Education (1-6) An in-depth analysis of current problems confronting the profession.

560. Administrative Problems of Physical Education in Schools (3) Solutions to problems emerging from the administration of physical education in schools, fitting physical education in the school's schedule, awards and budgets. Prerequisite: Ph.Ed. 491.

563. Motor Learning (3) Analysis of research evidence related to motor skills; characteristics of beginning and advanced performers; relevant learning principles.

565. Neuromuscular Performance (3) Integrative action of the neural and muscular systems in effecting human movement with emphasis on motor performance. Prerequisites: Ph.Ed. 480, 490.

575. MOTOR PERFORMANCE OF THE HANDICAPPED (3) Motor performance of physically handicapped and mentally retarded. Activities and therapeutic exercises for the formulation of individualized programs. Prerequisites: Ed.Ser. 409, E.E.C. 410.

576. INTERNSHIP IN ADAPTED PHYSICAL EDUCATION (3) Supervised internship in recreational, educational, or clinical situations; assessment of motor performances, evaluation of activities, and staff conference participation.

581. BIOMECHANICS (3) Kinetic and kinematic analyses of human motion utilizing electromyography and stroboscopic-photographic techniques. Prerequisite: Ph.Ed. 480.

582. ADVANCED KINESIOLOGY (3) Analysis of sports movements utilizing cinematography, electronic devices, and related research instruments.

583. SPECIAL TOPICS IN BIOMECHANICS (1-6) Critical review of current research in biomechanics, culminating in individual research projects. Prerequisite: Ph.Ed. 581 or 582.

584. ELECTROMYOGRAPHIC KINESIOLOGY (3) The theoretical background and practical application of electromyography in understanding human movement and the function of muscles. Prerequisites: Ph.Ed. 480, 484.

585. (Phsio. 585) APPLIED PHYSIOLOGY (3) Presentation of current thinking on physiological mechanisms with emphasis on physically active man. Prerequisite: 3 credits in physiology at the 400 or 500 level.

586. RESEARCH METHODS IN APPLIED PHYSIOLOGY (3) Historical and current procedures for evaluation of cardio-pulmonary function, metabolism, and thermal balance in man; lecture, demonstration, and student laboratory. Prerequisite: 3 credits in physiology at the 400 or 500 level.

588. SPECIAL TOPICS IN APPLIED PHYSIOLOGY (1-6) Critical discussion and evaluation of current research in applied physiology. Prerequisite: Ph.Ed. 585.

589. (Phsio. 589) PHYSIOLOGY OF PULMONARY RESPIRATION (2) Physiology of the lung including physical and chemical properties, synthesis of cellular constituents, gas exchange, and effects of unusual environments. Prerequisite: 3 credits of physiology at 400 or 500 level.

595. PHILOSOPHY OF SPORT AND PHYSICAL EDUCATION (3) Prerequisite: Ph.Ed. 491 or Rc.Pk. 465.

PHYSICAL SCIENCE (PH SC)

THOMAS A. WIGGINS, *Chairman of the Committee on Physical Science*
S-6 Osmond Laboratory

Degrees Conferred: D.Ed., M.Ed.

The M.Ed. program, designed to meet the needs of secondary school science teachers, requires at least 24 credits chosen from chemistry, physics, astronomy, mathematics, earth sciences, and biological sciences, including at least 9 each in chemistry and physics. In addition, a minor of at least 6 credits in education is required. The student must also complete a satisfactory term paper on a subject approved by the committee.

For admission to either the M.Ed. program or the D.Ed. program, the student is expected to have completed two years of college chemistry, one year of college physics at a level requiring calculus, mathematics through differential equations, and 18 credits in appropriate education and psychology courses.

For the D.Ed. degree, the student is required to complete 24 credits in physical science, including chemistry, earth sciences, mathematics, and physics, which *may* be (but are not required to be) in courses designed specifically for teachers. He is expected, beyond this, to complete 36 credits in standard 400- and 500-level courses, which *may not* be courses designed primarily for teachers; of these, 12 credits must be in chemistry, 12 in physics, and 12 in science and mathematics courses approved by the student's doctoral committee. In addition, 15 credits

in education courses and 15 credits of thesis research are required. The student's selection of science courses should include at least 6 credits in experimental physics or chemistry.

A limited amount of work can be done during summer terms or off campus, but a candidate must plan to be on the University Park Campus for at least four consecutive terms after he has been accepted as a D.Ed. candidate. The student will be required to take a candidacy examination after having completed about 30 credits of graduate study, and a comprehensive examination after having completed his required course work. He must also present and defend a thesis, which may be either an experimental study in physics or chemistry, or an investigation of a problem in the teaching of physical science.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

See also Earth Sciences, Mathematics, and Physics.

PHYSICS (PHYS)

ROLAND H. GOOD, JR., *Head of the Department*
104 Davey Laboratory

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Atwater, Barsch, Bleuler, Cutler, Eastman, Feuchtwang, Fleming, Frankl, Freed, Henisch, Herman, Kazes, Kendall, Madjid, McCammon, McCubbin, McKelvey, Müller, Pliva, Polo, Pratt, Skudrzyk, Strother, Thwaites, Vedam, Weber, Whitfield, and Wiggins.
Graduate Faculty: Associate Members Graetzer, Grotch, Lochstet, Nishikawa, Reed, Rendulic, Shaw, and Tsong.

Graduate instruction and research opportunities are available in visible and infrared spectroscopy, laser physics, solid state, field emission, thermionic emission, photoelectric emission, acoustics, low-temperature physics, nuclear physics, physics of high polymers and of carotenoids, electron spin resonance of solids, and various phases of theoretical physics.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by reading or introductory knowledge of one foreign language chosen from French, German, or Russian.

A bachelor's degree in physics or an allied field is required for admission to the M.S. and Ph.D. programs. Students who lack some of the usual upper-class undergraduate courses in physics may be requested to take additional course work without degree credit.

For admission to the M.Ed. program a student is required to have completed one year of general college physics plus two acceptable intermediate courses in physics, mathematics through integral calculus, and 18 credits in education and related psychology. The program requires at least 18 credits in physics, including approved laboratory work such as Phys. 560; at least 3 credits each in chemistry and mathematics; and at least 6 credits in education. With the approval of the head of the department the nonthesis option is available for the M.S. degree.

Students with a 2.50 junior-senior average in physics and mathematics will be considered for admission to the M.S., D.Ed., and Ph.D. programs. He will be considered with a 2.50 junior-senior average in all courses for admission to the M.Ed. program. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. Exceptions may also be made, at the discretion of the department, for applicants for doctoral programs who have satisfactorily completed master's degrees at other institutions.

PHYSICS (PHYS)

400. Intermediate Electricity and Magnetism (4)
402. Electronics (4)
406. Nuclear Physics (3)
410. Introduction to Quantum Mechanics (3)
412. Solid State Physics I (3)
413. Solid State Physics II (3)
419. (A.M. 419) Theoretical Mechanics (3)
420. Classical Thermodynamics (2)
421. Thermal Physics (2)
433. Mechanics and Fluid Physics for Teachers (3)
435. Electricity and Magnetism for Teachers (3)
443. Intermediate Acoustics (3)
454. Atomic and Nuclear Physics (3)
456. Atomic and Molecular Physics (3)
457. Experimental Physics (1-2 per term)
458. Intermediate Optics (4)
461. (A.M. 461) Theoretical Mechanics (3)
467. Intermediate Electricity and Magnetism (3)
470. Special Topics (1-9)
471. Quantum Theory of Atoms and Molecules (3)

512-513. Introduction to the Quantum Theory of Solids (3 each) Energy band theory; electrical, optical, and magnetic properties; lattice dynamics; transport theory. Prerequisites: Phys. 412, 517.

517. Statistical Mechanics (3) Classical and quantum statistics; statistical thermodynamics; the Boltzmann transport equation; methods illustrated with applications to physical problems. Prerequisites: Phys. 420, 561.

518. Advanced Topics in Thermodynamics and Statistical Mechanics (3) Selected topics related to nonequilibrium thermodynamics, many-body problem, fluctuations, and statistical theory of random processes. Prerequisite: Phys. 517.

524. Physics of Semiconductors (3) Band structures, theory of electron and hole conduction, transport properties, excess carrier distributions, p-n junctions, metal-semiconductor contacts, semiconductor surfaces. Prerequisite: Phys. 412.

525. Methods of Theoretical Physics (3) Vector and tensor analysis; generalized coordinate systems; matrices and linear vector spaces of finite and infinite dimensionality; calculus of variations. Prerequisite: advanced calculus.

526. Methods of Theoretical Physics (3) Continuation of Phys. 525: complex variables; Hilbert space; Green's functions; orthogonal functions and boundary value problems. Prerequisite: Phys. 525.

530. Theoretical Mechanics (3) Newtonian mechanics; Lagrange's equations, Hamilton's principle; Hamilton's equations; coupled systems; waves in strings, central field problem; rigid bodies; elasticity; hydrodynamics.

532. Advanced Theoretical Mechanics (3) Least action principle, canonical transformations, Lagrange and Poisson brackets, Hamilton-Jacobi equations, classical theory of fields. Prerequisite: Phys. 530.

533. Theoretical Acoustics (3) Vibrating systems; transmission of disturbances through elastic and viscoelastic media. Prerequisite: Phys. 530.

550. (A.M. 550) Applied Group Theory (3) Representations of discrete and continuous groups, applications to theoretical physics and differential equations, varying emphasis on the specific applications. Prerequisite: A.M. 510.

553-554. Nuclear Physics (3 each) Discussion and theoretical interpretation of basic experiments involving atomic nuclei and nuclear radiations. Prerequisite: Phys. 562.

557. ELECTRICITY AND MAGNETISM (3) Electro- and magnetostatics, Maxwell's equations, boundary value problems, electric and magnetic properties of material media.

558. ADVANCED ELECTRICITY AND MAGNETISM (3) Energy and momentum in the field, radiation theory, classical relativistic electron theory. Prerequisite: Phys. 557.

561-562. QUANTUM MECHANICS (3 each) The basic theory of wave and matrix mechanics, approximation methods, applications. Prerequisite: Phys. 530.

563-564. ADVANCED QUANTUM MECHANICS (3 each) Relativistic wave equations, quantum field theory, other advanced quantum theoretical topics. Prerequisite: Phys. 562.

571. ATOMIC PHYSICS (3) Experimental basis of modern physics; atomic spectra and structure, nuclear phenomena.

PHYSIOLOGY (PHSIO)

ADAM ANTHONY, *Chairman of the Committee on Physiology*
418 Life Sciences Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Amann, Anthony, Bardin, Baumgardt, Bortree, Buskirk, Cornwell, Dunson, Hymer, Jeffries, Leach, McCarl, Mendez, Morgan, Mortimore, Mueller, B. Pubols, Rhoades, Smyth, and Wickersham.
Graduate Faculty: Associate Members Eberhart, Hollis, Jefferson, Kollias, Martin, Mitchell, Neely, Neff, Nicholas, L. Pubols, Rose, Scholz, Wade, Wangness, and Whitfield.

This is an intercollege program designed to enable students to obtain an integrated series of courses encompassing both the fundamentals of physiology and advanced training in a specialized area.

Graduate instruction in physiology is under the direction of a program committee composed of graduate faculty representing several departments or groups actively participating in the physiology program, including the areas of animal science, biochemistry, biophysics, and zoology, and the Human Performance Research Laboratory. The instructional staff is composed of the program committee as well as faculty in those departments offering graduate courses in various areas of specialization in physiology. The program, including courses, laboratory experience, and original research, is designed for completion in three to four academic years. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests.

The entering student who lacks adequate preparation in chemistry, mathematics (through calculus), physics, or biological science must make up the deficiency early in his graduate program. All candidates (master's and doctoral) must complete a general basic laboratory course in physiology (combined cellular, mammalian, and comparative) before choosing an area of specialization. Possible areas of specialization are cellular and subcellular physiology, environmental physiology, endocrinology, reproductive physiology, applied physiology (human performance), physiology of nutrition and metabolism, neurophysiology, or comparative physiology. The graduate committee for majors shall be appropriately represented by members of the physiology program committee and those of the area of specialization who shall have the responsibility and jurisdiction for determining the course program and research acceptable in satisfying degree requirements. The nonthesis option is available for the M.S. degree.

The following courses are available for physiology majors, and their descriptions may be found under the offerings of several departments: Anthy. 401; A.I. 514; A.Ntr. 401, 402, 505; Bioch. 401, 402, 417, 437, 438, 501, 519; Biol. 462, 472, 473, 475, 479, 538, 539, 541, 583; Bphys. 473, 474, 475, 580, 588; D.Sc. 427, 431, 512, 515, 521; Micrb. 401, 508; Nutr. 452, 457, 459, 552, 557; Ph.Ed. 480; Psy. 402, 403, 503; V.Sc. 535.

The following courses in physiology and biochemistry are offered at The Milton S. Hershey Medical Center: Anat. 505, 510, 535; Bchem. 502, 503, 513, 523, 540, 570, 590; Phsio. 520, 521, 525, 530, 550, 570, 590. Descriptions of these courses may be found under the designated program.

PHYSIOLOGY (PHSIO)

501. SEMINAR (1 per term)

532. REPRODUCTIVE PHYSIOLOGY (3) Physiology of male and female reproductive systems, including synthesis, regulation of secretion and mechanism of action of the steroids and polypeptide hormones involved. Prerequisites: Phsio. 520, 521.

534. HEART AND SKELETAL MUSCLE (2) Discussion of structure, chemistry, and physiology of heart and skeletal muscle. Prerequisites: Phsio. 520, 521.

536. GASTROINTESTINAL PHYSIOLOGY (2) Mechanisms of absorption and secretion by stomach, intestine, pancreas, and gallbladder. Neural and hormonal regulation, bioelectric potentials, pathophysiology. Prerequisite: Phsio. 521.

571. (Biol. 571) ANIMAL PSYSIOLOGY (2) Physiology and fluid transport mechanisms; examination of the distribution and regulation of body fluids, blood and hemodynamics. Prerequisite: 3 credits in physiology.

572. (Biol. 572) ANIMAL PHYSIOLOGY (2) Examination of nutrition, metabolism, and respiration as they relate to subcellular, cellular, and organ organizational levels of the whole animal. Prerequisite: 3 credits in physiology.

573. (Biol. 573) ANIMAL PHYSIOLOGY (2) Detailed examination of animal reproduction, endocrine secretion and control, neural muscular activity, central nervous system correlates, and special senses. Prerequisite: 3 credits in physiology.

574. (Biol. 574) ANIMAL PHYSIOLOGY LABORATORY (1-6) Selected problems using advanced physiological techniques to study transport mechanisms, circulation, excretion, respiration, metabolism, and neuroendocrines. Prerequisite: Biol. 473.

585. (Ph.Ed. 585) APPLIED PHYSIOLOGY (3) Presentation of current thinking on physiological mechanisms with emphasis on physically active man. Prerequisite: 3 credits in physiology at the 400 or 500 level.

589. (Ph.Ed. 589) PHYSIOLOGY OF PULMONARY RESPIRATION (2) Physiology of the lung including physical and chemical properties, synthesis of cellular constituents, gas exchange, and effects of unusual environments. Prerequisite: 3 credits of physiology at 400 or 500 level.

PLANT PATHOLOGY (PPATH)

JAMES TAMMEN, *Head of the Department*
211 Buckhout Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Bloom, Boyle, Cole, Kneebone, Lewis, Lukezic, Merrill, Mills, P. Nelson, R. Nelson, Schisler, and Tammen.
Graduate Faculty: Associate Members Hyre, Lacasse, Leath, Stouffer, and Wuest.

Plant pathology is the study of disease in plants and concerns the dynamic interaction between the plant, the causal agent (bacteria, fungi, viruses, nematodes, etc.), and their environments. A student prepares for a professional career in research, teaching, extension, or industry through

advanced studies of the principles of plant infection, the physiology of disease in plants, the ecology of root diseases, the nature and inheritance of disease resistance in plants, epidemiology, ecology and physiology of air pollution injury to plants, or plant disease control by biological or chemical means. A student also may specialize in the nature and control of the diseases of forest trees, agronomic or horticultural crops, and commercial mushrooms. Advanced studies in applied mycology, related to the production of the commercial mushroom, also may be taken. Modern, well-equipped laboratories, controlled environment facilities and greenhouses, and well-developed field research areas are available for graduate study.

Competency in foreign language is not required for the Ph.D. degree; however, depending upon the nature of the thesis research and with the advice and consent of the doctoral advisory committee, competency in a foreign language may be judged to be an essential part of the doctoral studies of certain students.

For admission a student must present 42 credits in the natural sciences, including a minimum of 15 credits in the plant sciences and a minimum of 15 credits in mathematics, chemistry, or physics. Students with a strong background in agronomy, biochemistry, biophysics, botany, forestry, genetics, horticulture, or microbiology are usually well prepared for advanced study in plant pathology.

Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests.

PLANT PATHOLOGY (PPATH)

401. Theory and Concepts of Plant Pathology (3) *Mr. Merrill*
402. Diseases of Economic Plants (2) *Mr. Merrill*
408. Plant Pathological Techniques (3) *Mr. Bloom*
420. Plant Pathogenic Bacteria (3) *Mr. Lukezic*
422. Introduction to Plant Virology (3) *Mr. Smith*
424. Environmental Pathology (3) *Mr. Lacasse*
429. Phytonematology (3) *Mr. Bloom*
430. History of Plant Pathology (2) *Mr. Merrill*

501. Clinical Plant Pathology (1-3) Diagnosis and prognosis of disease; observe and evaluate the implementation of control practices. Prerequisite: P.Path. 408. *Mr. Cole*

540. Plant Disease Control (3) Principles of plant disease control, including theoretical considerations involved in control by chemical and nonchemical means. *Mr. Cole*

541. Physiology of Plant Disease (3) Physiology of the diseased plant, including the host response to the pathogen and parasitic properties of the pathogen. Prerequisite: Biol. 443. *Mr. Lukezic*

542. Epidemiology of Plant Diseases (4) Disease development in populations of plants, with emphasis on the impact of environment and control practices on rate of development. Prerequisite: 9 credits in plant pathology.

543. Pathogen Variation and Host Resistance (3) Mechanisms and implications of genetic variation in plant pathogens related to breeding for disease resistance in plants by genetic means. *Mr. Ayers*

544. Pathological Plant Anatomy (2) Structural manifestations occurring in diseased plants. Prerequisites: Biol. 407, P.Path. 408. *Mr. P. E. Nelson*

560. Principles of Plant Pathology (3) Open-ended discussions of concepts of plant pathology, with emphasis on their interrelationships and their significance to the science. *Mr. R. R. Nelson*

POLITICAL SCIENCE (PL SC)

ROBERT S. FRIEDMAN, *Head of the Department*
107 Social Sciences Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Albinski, Aspaturian, Atwater, Brown, Chang, Friedman, Kochanek, Mowitz, and Silva.
Graduate Faculty: Associate Members Eisenstein, Gilberg, Keynes, King, Kingsland, LaPorte, Lee, Loomis, and O'Connor.

M.A. candidates will be comprehensively examined in American politics, comparative politics, international relations, political philosophy, or public administration. Candidates offering the thesis plan will also offer course work in one other of these substantive fields, or from among selected empirical theory-methodology courses. Candidates offering the nonthesis plan will offer course work in two of the above six fields. Ph.D. candidates will be comprehensively examined in four of the above fields, or in three departmental fields, and in a minor field or fields. Course work in empirical theory and scope and methodology is required. The communication and foreign language requirement for the Ph.D. may be satisfied by competence in approved skills selected from among foreign languages, statistics or mathematics, and computer science.

Students with a 3.00 junior-senior average and appropriate course backgrounds, including at least the equivalent of 12 credits in political science, will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. At the master's level two letters of recommendation and scores on the Graduate Record Examination (disciplinary, verbal, and quantitative ability) are required. Admission to the Ph.D. program will entail evaluation of two letters of recommendation, scores on the Graduate Record Examination (disciplinary, verbal, and quantitative ability), and previous scholastic performance.

POLITICAL SCIENCE (PL SC)

401. POLITICAL BEHAVIOR (3) *Messrs. King and Wissel*
403. THE LEGISLATIVE PROCESS (3) *Messrs. Keynes and Wissel*
411. AMERICAN POLITICAL THEORY (3) *Messrs. Spence and Wikse*
412. INTERNATIONAL ORGANIZATION: ECONOMIC AND SOCIAL FUNCTIONS (3) *Mr. Atwater*
413. GOVERNMENT AND POLITICS OF THE SOVIET UNION (3) *Messrs. Aspaturian, Atwater, and Gilberg*
414. FOREIGN POLICY OF THE SOVIET UNION (3) *Mr. Aspaturian*
415. INTERNATIONAL ORGANIZATION: POLITICAL AND SECURITY FUNCTIONS (3-6) *Miss Loomis; Messrs. Aspaturian, Atwater, and Brown*
416. INTERNATIONAL LAW (3) *Miss Loomis*
417. AMERICAN LOCAL GOVERNMENT AND ADMINISTRATION (3) *Messrs. Johnson, Lee, and O'Connor*
418. INTERNATIONAL RELATIONS THEORY (3) *Miss Loomis*
419. BUREAUCRACY AND PUBLIC POLICY (3) *Messrs. Friedman, Johnson, and Lee*
425. GOVERNMENT AND POLITICS OF THE AMERICAN STATES (3) *Messrs. Friedman and O'Connor*
426. POLITICAL PARTIES (3) *Miss Silva, Mr. King*
427. POLITICAL OPINION (3) *Miss Silva; Messrs. O'Connor and Wissel*
431. ANCIENT AND MEDIEVAL POLITICAL THEORIES (3) *Messrs. Spence and Wikse*
433. (L.S. 433) THE LAW OF LABOR-MANAGEMENT RELATIONS (3)
438. NATIONAL SECURITY POLICIES (3) *Mr. Brown*
441. ANGLO-AMERICAN LEGAL SYSTEMS (3) *Messrs. Eisenstein and Keynes*
442. AMERICAN FOREIGN POLICY (3) *Miss Loomis; Messrs. Atwater and Brown*
443. CURRENT PROBLEMS IN AMERICAN FOREIGN POLICY (3) *Messrs. Atwater and Brown*

444. GOVERNMENT AND THE ECONOMY (3) *Mr. Wissel*
445. ADMINISTRATIVE LAW (3)
447. CONSTITUTIONAL LAW: THE FEDERAL SYSTEM (3) *Miss Silva, Mr. Keynes*
448. CONSTITUTIONAL LAW: FIRST AMENDMENT FREEDOMS (3) *Miss Silva*
450. CANADIAN AND AUSTRALIAN POLITICS AND FOREIGN POLICIES (3) *Mr. Albinski*
451. COMPARATIVE POLITICAL ANALYSIS (3) *Mr. Albinski*
452. GOVERNMENTS AND POLITICS OF EASTERN EUROPE (3) *Mr. Gilberg*
453. POLITICAL PROCESSES IN UNDERDEVELOPED SYSTEMS (3) *Messrs. Chang, Kingsland, Kochanek, LaPorte, and Myers*
454. GOVERNMENT AND POLITICS OF AFRICA (3) *Messrs. Brown and Kingsland*
455. GOVERNMENTS AND POLITICS OF WESTERN EUROPE (3) *Mr. Gilberg*
456. POLITICS AND INSTITUTIONS OF LATIN-AMERICAN NATIONS (3) *Mr. Myers*
457. INTERNATIONAL POLITICS OF LATIN AMERICA (3-6) *Mr. Myers*
458. GOVERNMENT AND POLITICS OF EAST ASIA (3-6) *Mr. Chang*
459. GOVERNMENT, POLITICS, AND INTERNATIONAL RELATIONS OF SOUTH ASIA (3) *Mr. Kochanek*
460. LIBERAL AND DEMOCRATIC POLITICAL THEORY (3) *Messrs. Spence and Wikse*
461. AUTHORITARIAN AND ELITIST POLITICAL THEORY (3) *Messrs. Spence and Wikse*
462. MARXIST AND SOCIALIST POLITICAL THEORY (3) *Messrs. Spence and Wikse*
468. INTERNATIONAL RELATIONS OF EAST ASIA (3) *Mr. Chang*
469. INTERNATIONAL RELATIONS IN SOUTH ASIA (3-6) *Mr. Kochanek*
473. CONSTITUTIONAL LAW: CIVIL RIGHTS (3) *Miss Silva*
494. DIRECTED READINGS IN POLITICAL SCIENCE (1-6)
495. DIRECTED RESEARCH IN POLITICAL SCIENCE (1-6)
499. FOREIGN STUDY IN GOVERNMENT (2-6)

500. POLITICAL POWER (3-6) Subject to be announced.

505. EXECUTIVE POWER (3-6) *Miss Silva*

509. SCOPE AND METHOD OF POLITICAL SCIENCE (3-6) *Mr. King*

512. COMPARATIVE POLITICAL SYSTEMS (3-9) *Messrs. Albinski, Chang, Kochanek, and Petras*

513. SEMINAR IN COMPARATIVE POLITICAL PARTIES (3-6) Nature, function, organization, and leadership of parties; party systems, political culture, voting, and the institutional framework. *Messrs. Albinski and King*

515. INTERNATIONAL POLITICS (3-6)

516. SEMINAR IN INTERNATIONAL RELATIONS THEORY AND METHODOLOGY (3) A detailed analysis of major traditional and contemporary theory-building efforts and contemporary research techniques and orientations in international relations. *Miss Loomis*

517. INTERNATIONAL ORGANIZATION (3-6) *Messrs. Aspaturian and Atwater*

521. MODERN DEMOCRATIC POLITICAL THEORY (3-6)

522. COMPARATIVE FOREIGN POLICIES (3-6) Major policies of selected nations which bear upon the search for international peace and security. *Mr. Aspaturian*

523. SOVIET POLITICAL BEHAVIOR (3) Forces which shape rivalries for power; decision-making processes; areas of agreement and dissent. *Messrs. Aspaturian and Gilberg*

524. FOREIGN POLICIES OF THE SOVIET BLOC (3-6) Major policies, the decision-making process, and the impact upon component members and external rivals for power. *Mr. Aspaturian*

525. COMPARATIVE AMERICAN STATE AND LOCAL POLITICS (3-6) Literature and research in comparative state and local political systems in the United States. *Messrs. Friedman and O'Connor*

527. POLITICS AND LEGISLATIVE BEHAVIOR (3-6) Social factors which shape and determine the attitudes and decisions of American legislators and legislative bodies. *Mr. Keynes*

528. (Ed.Adm. 528) POLITICS AND EDUCATION (3) Social forces which shape the educational system and determine national, state, and local educational policies.

529. Federal Systems (3-6) Features of the American federal system compared with those of other nations using the federal form.

530. Public Law (3-6) The nature of law and its role in modern society. *Miss Silva, Mr. Eisenstein*

531. Marxism and Political Socialist Theories (3) A systematic analysis and appraisal of major premises and deductions. *Mr. Aspaturian*

532. Empirical Political Theory (3-6) The impact of scientific method upon traditional political thought. *Mr. Keynes*

546. Judicial Process (3) Court functions in the political process; sources and limits of judicial power; perceptions of the judicial role; judicial decision making. Prerequisite: 12 credits in political science. *Miss Silva; Messrs. Eisenstein and Keynes*

554. African Political Systems (3-6) Impact of European colonialism; cultural and anthropological factors in political development; modernization and analysis of selected problems in contemporary Africa. Prerequisite: 3 credits of comparative government or international relations at the 400 level. *Mr. Brown*

571. Theory of Public Administration (3-6) The role of the executive in modern government; the objectives of public administration; theories of administrative organization and practice. *Mr. Mowitz*

572. International Development Administration (3-6) The execution of foreign policies through national and international public and private organizations. *Mr. LaPorte*

573. Comparative Public Administration (3-6) Administrative systems of selected nations on a functional basis; relationship between culture, economic and social systems, and public administration. *Mr. LaPorte*

574. Seminar in the Administration of United States Foreign Affairs (3) Effect of cross-cultural operations on the normal process of administration of United States foreign affairs. *Messrs. Brown and LaPorte*

575. Government Manpower Management (3) Government personnel systems; current trends and problems; essentials of recruitment, classification and pay, ratings, supervision, training, and discipline.

576. Government Fiscal Decision Making (3) The role of the executive in fiscal planning; budget preparation; expenditure control; tax assessment and collection; investment of public funds.

577. Organization and Systems Management (3) Principles of government organization; management surveys; work measurement; methods of achieving efficiency and economy. *Mr. Mowitz*

578. Urban Administrative Systems (3) Urban areas as administrative and policy systems; urban responses to problems of policy planning and implementation; approaches to urban analysis.

579. Methods of Analysis and Measurement in Public Administration (3) Examination and application of analytical techniques for evaluating organizational performance and program effectiveness in government agencies.

580. Internship in Public Administration (6)

581. Public Management Information Systems (3) Examination of the role of management information in public organizations; establishment of information requirements for public programs. Prerequisites: Pl.Sc. 571, 579.

584. Research Seminar in Public Administration (1-6) Application of research methods to problems of organization, management, and policy in public agencies; preparation of research project and report.

594. Readings in Political Science (1-6) Directed readings in selected areas of the discipline.

595. Research in Political Science (1-6) Directed research in selected areas of the discipline.

POULTRY SCIENCE (PTYSC)

KENNETH GOODWIN, *Head of the Department*
214 Animal Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Bressler, Buss, Goodwin, Graves, Hale, Leach, MacNeil, and Mueller.

The department offers two types of graduate programs: (1) a program in poultry science, with one of the following major fields of interest: genetics, physiology, nutrition, behavior, food science, or poultry management; and (2) an interdepartmental program in one of the following disciplines: genetics, physiology, food science, animal nutrition, or ecology.

In either case, the student's major program and his thesis research will be under the direction of a faculty member in the Department of Poultry Science. The communication and foreign language requirement for the Ph.D. degree may be satisfied by reading ability in one foreign language.

Admission requirements include 30 credits in biology, chemistry, mathematics, and physics. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

POULTRY SCIENCE (PTYSC)

402. SPECIAL TOPICS (3-12) *Staff*
405. POULTRY PRODUCTION TECHNOLOGY (3) *Mr. Keene*
462. (Biol. 462) ANIMAL BEHAVIOR — ETHOLOGY (3)
463. Biol. 463, Psy. 463) ANIMAL BEHAVIOR LABORATORY (1-2)

502. ADVANCED POULTRY NUTRITION (2-4) *Mr. Leach*

503. POULTRY FARM MANAGEMENT (3) An analysis of poultry farm management problems and the application of research methods to a specific problem. *Mr. Bressler*

504. POULTRY MEAT AND EGG TECHNOLOGY (3) Analysis of current industry programs, effects of specific procedures on product quality, development of research programs. Offered even years. *Mr. MacNeil*

582. (Biol. 582, Psy. 582) RESEARCH IN ANIMAL BEHAVIOR (2-6 per term) Research in special areas of animal behavior involving field or laboratory work. *Messrs. Graves and Hale*

NOTE: *See Animal Science under "Other Elective Graduate Courses." Also see Food Science.*

PSYCHOLOGY (PSY)

MERRILL E. NOBLE, *Head of the Department*
417 Moore Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Berman, Cofer, Cornwell, Draguns, Gorlow, Greenhill, Guthrie, Hale, Hall, Harris, Landy, Leibowitz, Lundy, Martin, Mitzel, Noble, Palermo, Seibel, Sherif, Stern, Taylor, Thevaos, Thomas, Trumbo, Urban, and Warren.
Graduate Faculty: Associate Members Blashfield, Craighead, Dubin, Farr, Kazdin, Kerr, Mahoney, Piers, Ravizza, Ray, Seaver, Shotland, Weimer, and Whaley.

Graduate instruction and research opportunities are available in the following areas of psychology: general experimental, physiological and comparative, perception, social and personality, developmental, child, clinical, industrial-organizational, engineering and human factors, verbal learning, and psycholinguistics.

The communication and foreign language requirement for the Ph.D. degree does not specify a foreign language but a student must demonstrate proficiency in English.

Special research and training facilities include the Penn State Anechoic Chamber, the University Computation Center, the Animal Behavior Laboratory, the Psychology Clinic, the Division of Counseling, and the Special Education unit.

Requirements for admission include a broad undergraduate preparation, a minimum of 9 credits in psychology, and a satisfactory graduate student rating on the Miller Analogies Test and the Graduate Record Examination (General). Students with a 3.20 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.20 grade-point average may be made for students with special backgrounds, abilities, and interests. Applicants with master's degrees will have their admission evaluated with emphasis on the quality of their graduate programs.

PSYCHOLOGY (PSY)

402. SENSATION AND PERCEPTION (3)
403. INTRODUCTORY PHYSIOLOGICAL PSYCHOLOGY (3)
404. CONDITIONING AND LEARNING (3)
405. THE EXPERIMENTAL PSYCHOLOGY OF VISUAL PERCEPTION (3)
408. COMPARATIVE PSYCHOLOGY (3)
409. TECHNIQUES IN LABORATORY EXPERIMENTATION (2-6)
410. HISTORICAL ANTECEDENTS OF PSYCHOLOGY (3)
411. SYSTEMS OF PSYCHOLOGY AND THE RECENT PAST (3)
412. ABNORMAL PSYCHOLOGY (3)
413. BIOGRAPHICAL PSYCHOLOGY (3)
414. HUMANISTIC PSYCHOLOGY (3)
415. INTERMEDIATE EXPERIMENTAL DESIGN (3)
417. SOCIAL PSYCHOLOGY (3)
418. MEASUREMENT OF PERSONALITY (3)
420. (Ling. 420) ADVANCED PSYCHOLINGUISTICS (3)
421. ADVANCED COGNITIVE PSYCHOLOGY (3)
425. CHILD PSYCHOLOGY (3)
426. ADOLESCENCE (2-3)
430. MEMORY AND VERBAL LEARNING (3)
431. INDUSTRIAL PSYCHOLOGY (3)
432. INTRODUCTORY ENGINEERING PSYCHOLOGY (3)
433. PSYCHOLOGY OF OCCUPATIONAL BEHAVIOR (2)
434. INFORMATION-PROCESSING LABORATORY (1-6)
436. MENTAL HEALTH IN SCHOOLS (3)
437. PSYCHOLOGY OF ADJUSTMENT (3)

438. Theory of Personality (3)
440. Psychology Projects (1-6)
441. Industrial Motivation and Morale (3)
445. (I.F.S. 445) Development Throughout Adulthood (3)
450. (Ed.Psy. 450) Principles of Measurement (3)
452. Laboratory in Sensory Processes (2-4)
453. Neuroanatomy Laboratory (1)
455. Physiological Psychology Laboratory (3)
456. Laboratory in Psychophysiology (2-4)
457. Experimental Social Psychology (4)
463. (Biol. 463, Pty.Sc. 463) Animal Behavior Laboratory (1-2)
474. Psychology of Exceptional Children (3)
482. Introduction to Clinical Psychology (3)

500. Seminar: Introduction to Graduate Study (2-6) Required of all new graduate majors in psychology.

503. Physiological Psychology (2-6) Correlations between structure and function of nervous system and human consciousness; laws and theories in fields of sensation, attention, association, affection, and thought. Prerequisite: 9 credits in psychology.

505. Research Problems in Psychology (1-15) Prerequisite: 12 credits in psychology.

509. Seminar in Conditioning and Learning (3-9) Prerequisite: Psy. 404 or Ed.Psy. 421.

510. History of the Higher Mental Processes (3) Stress upon theoretical, conceptual, and methodological problems involved in studying human thinking, language, memory, cognition, and other skills. Prerequisite: Psy. 410 or 411.

511. Seminar in Contemporary American Psychology (1-9) Critical review of readings on a topic of current interest, either in content or methodology, within psychology. Prerequisite: 9 credits in psychology.

513. (Phil. 513) Principles and Methods of Empirical Science (3) Scientific methodologies and their presuppositions, with special emphasis on behavioral and social sciences.

515. Advanced Statistics in Psychology and Education (3) Correlation theory and methods, discriminant function, and factor analysis; applications to mental test theory. Prerequisite: Psy. 415 or Ed.Psy. 506.

516. Seminar in Quantitative Models (3-9)

517. Advanced Social Psychology (3) Problems of theory and of research methods with emphasis on persisting issues relevant to contemporary developments in social psychology. Prerequisites: Psy. 417; Psy. 15 or Stat. 200.

518. Projects in Experimental Psychology (2-4) Individual experimental projects; seminars on experimental design and instrumentation.

520. (Ling. 520) Seminar in Psycholinguistics (3) The relationship between the behavioral, probabilistic view and the structuralist, deterministic view of language as a system of habits.

527. Statistical Inference and Experimental Design (3) Probability theory, sampling distributions, analysis of variance and covariance, analysis of trend, nonparametric statistics, experimental design. Prerequisite: Psy. 415 or Ed.Psy. 506.

529. (I.F.S. 529) Seminar in Child Development (1-6) Readings and reports on recent findings in child development. Prerequisites: 6 graduate credits in child development, child psychology, or educational psychology, plus 3 in statistics.

531. Seminar in Performance Theory (3-9) Topics in theory and research on human performance in perceptual-motor and information-processing tasks. Prerequisite: Psy. 432.

533. Seminar in Engineering Psychology (2-9) Design and operation of machines, man-machine allocation, the man-machine interface, displays, system-design, decision making, image evaluation, and motor behavior. Prerequisite: Psy. 432.

535. Developmental Psychology (2-3) Developmental principles and concepts applied to psychological processes, with special reference to the experimental literature. Prerequisite: 9 credits in psychology.

536. (I.F.S. 536) Research Methods in Developmental Processes (3) Methodological issues in research on varying stages of development across the individual life-span. Prerequisites: 6 credits in individual development or psychology and a course in statistics.

537. Seminar in Industrial Psychology (1-9) Prerequisite: Psy. 431.

538. Psychology of Personnel Development (3) Industrial training in relation to psychological learning theory and experimental findings. Prerequisite: Psy. 431 or Ed.Psy. 421.

539. Seminar in Motivation and Emotion (3-9) Systematic status of instinct, drive, motive, will, purpose; methodology and results of physiological, experimental, and clinical investigation of basic drives.

540. Seminar in Clinical Problems (1-9) Contemporary psychological theory, research, and methodology in relation to clinical psychology. Prerequisites: Psy. 542, 560.

541. Personality Theory (3-4) Contemporary theories of personality; relevant research. Prerequisite: Psy. 438.

542. Psychopathology (3-4) Theories of pathological behavior with reference to clinical and experimental data. Prerequisite: Psy. 412.

545. Seminar in Verbal Learning and Verbal Behavior (1-9)

549. (I.F.S. 549) Developmental Theory (3) Conceptual frameworks and major contributions to the study of individual development across the life-span. Prerequisite: 6 credits at the 400 level in individual development or psychology.

555. Theory and Practicum in Clinical Assessment (3-9) Theoretical issues and research in clinical assessment with special reference to administration and interpretation of testing procedures and clinical interviewing. Prerequisites: Psy. 541 or 542, and a course in measurement.

558. Clinical Child Psychology (3-9) Psychopathology of childhood; theories of etiology; diagnosis and treatment. Prerequisites: Psy. 555, 561.

559. (S.Psy. 559) The Individual Psychological Examination (3) Demonstrations and practice in widely used ability and aptitude tests; psychological report writing. Prerequisites: 15 credits in psychology and a course in measurement.

560. Practicum in Clinical Methods (1-6) Supervised practice in the Psychology Clinic, including assessment, therapy, report writing, and staff participation. Prerequisite: Psy. 555.

561. Clinical Practicum with Children (1-6) Diagnosis and counseling of child-parent problems of learning and adjustment. Prerequisites: Psy. 425, 426, 555.

569. Advanced Theory and Practicum in Counseling and Psychotherapy (3-9) Theoretical issues, research, and practicum experience in psychotherapy.

571. Seminar in Social Psychology (3-9) Historical development of theory and methods; determinants and principles of complex social or interactional behavior; contemporary problems and research.

580. Theory and Construction of Attitude Scales (3) Measurement of social, political, commercial, and industrial attitudes; questionnaire designs. Prerequisite: 3 credits in statistics.

581. Experimental Study of Primate Behavior (3) Taxonomy of contemporary species of primates; ontogeny of learning, perception, and affective behavior; interspecies comparisons of behavior.

582. (Biol. 582, Pty.Sc. 582) Research in Animal Behavior (2-6 per term) Research in special areas of animal behavior involving field or laboratory work.

589. Problems in Clinical Research (1-6) Prerequisite: Psy. 415.

591. Seminar on Teaching Psychology (1-3) Objectives and content of psychology; organization and presentation of material; teaching aids and techniques.

PUBLIC ADMINISTRATION (PUB A)

ROBERT J. MOWITZ, *Director of the Institute of Public Administration*
208 Social Sciences Building

Degree Conferred: M.P.A.

Graduate Faculty: Senior Members Mowitz and Riew.
Graduate Faculty: Associate Members LaPorte, Lee, and Westby.

All candidates take a core program consisting of six seminars which cover the theoretical, methodological, and technological components of public management science. An additional 12 hours may be elected, permitting the student to focus upon such areas as general public administration, systems analysis, management information systems, urban systems administration, natural resources administration, human resources administration, or any other related substantive area.

Candidates for admission ordinarily will have at least 12 hours of undergraduate credit in the social sciences. Candidates for the degree may be required to take some courses without graduate credit in order to complete a major designed for their professional needs.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

PUBLIC ADMINISTRATION (PUB A)

F. FREDERICK NEUBAUER, *Chairman, Public Administration Program at Capitol Campus*
Middletown, Pa. 17057

Degree Conferred: M.P.A.

Graduate Faculty: Senior Member Neubauer.
Graduate Faculty: Associate Members Brown, Gilmore, Murty, Poore, and Woodruff.

This program is intended for individuals who are seeking or are currently engaged in professional careers as administrators, project directors, or staff analysts in urban and municipal government, state government, health and welfare organizations, and other public service agencies. In order to complete a program designed for their professional needs, students may be required to complete preparatory work in basic mathematics, statistics, micro- and macroeconomics, accounting, and introduction to computer programming. In addition, students must have sufficient preparation in political science and other social sciences, or equivalent experience, in order to perform satisfactorily in the program.

At the graduate level all students take 15 credits of common core courses from the areas of administrative theory, organizational behavior, the political process, and research methods. The core also requires a professional paper. In addition, 15 credits of electives are required in areas such as program planning and evaluation, personnel management, labor relations, fiscal management, urban problems, regional planning, current economic issues, quantitative decision-models, and other related areas.

Students with a 2.75 junior-senior average will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.75 grade-point average may be made for students with special backgrounds, abilities, and interests. Applicants are required to present their scores on the Graduate Record Examination (verbal and quantitative ability) as part of their application materials.

Courses applicable to this program are listed under the program in administration at the Capitol Campus.

RECREATION AND PARKS (RC PK)

BETTY VAN DER SMISSEN, *Associate Dean for Graduate Study and Research*
275 Recreation Building

Degrees Conferred: M.S., M.Ed.

Graduate Faculty: Senior Members Gross, Nelson, and van der Smissen.
Graduate Faculty: Associate Members Harris, Kuss, Lundegren, Mobley, and Stoedefalke.

The graduate program is designed to prepare students for administrative, supervisory, research, and teaching positions in public recreation and park systems, in colleges and universities, in voluntary agencies, and in institutions.

The program is oriented to meet the specific needs and research interests of the candidate. Areas of specialization include (1) recreation and park administration, including park planning, (2) recreation program supervision and administration, (3) camping, outdoor education, and outdoor interpretive services, and (4) therapeutic recreation.

The master's degree may be earned in the major program of recreation and parks. At the doctoral level, the Ph.D. and D.Ed. may be earned with a specialization in recreation and parks within the physical education major. Write for details.

For admission to the graduate program, a bachelor's or master's degree is required in recreation, park administration, or in a related field, e.g., forestry, landscape architecture, sociology, psychology, physical education, education, or fine arts. Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests.

RECREATION AND PARKS (RC PK)

420. OUTDOOR RECREATION (3)
425. INTERPRETIVE SERVICES (3)
430. OUTDOOR EDUCATION (3)
440. CAMP ADMINISTRATION (3)
456. RECREATION PROGRAM ORGANIZATION (3)
458. DYNAMICS OF RECREATION GROUPS (3)
461. COMMUNITY RECREATION (3)
465. ADMINISTRATION OF RECREATION AND PARKS (3)
470. METROPOLITAN PARK MANAGEMENT (3)
475. THERAPEUTIC RECREATION IN THE COMMUNITY (3)
477. THERAPEUTIC RECREATION IN THE REHABILITATION SETTING (3)
496. SPECIAL PROJECTS (1-6)

500. (Ph.Ed. 500) INDIVIDUAL STUDY AND RESEARCH PROJECTS (1-10) Prerequisite: Rc.Pk. 530.

515. PROGRAM DEVELOPMENT AND SUPERVISION (3) Critical analysis of the individual, political, and societal determinants of recreation programming; demonstration projects; evaluative procedures, research functions in programming. Prerequisite: Rc.Pk. 456.

520. SEMINAR IN CAMP ADMINISTRATION (3) Values inherent in the camp experience; critical analysis of philosophical choices and sponsor objectives as influencing program development. Prerequisite: Rc.Pk. 230 or 430.

530. (Ph.Ed. 530) RESEARCH TECHNIQUES IN HEALTH AND PHYSICAL EDUCATION AND RECREATION (3)

533. RECREATION STUDIES, SURVEYS, AND APPRAISALS (3) Advanced research procedures related to special recreation and park problems. Prerequisites: Rc.Pk. 530 and 3 credits in statistics.

540. PUBLIC RECREATION LANDS (3) Planning recreation lands; legislation, financing, intergovernmental coordination to acquire and develop open space land, urban recreation and park master plan.

550. SEMINAR IN RECREATION AND PARKS (1-6)

560. ADMINISTRATIVE PROBLEMS OF RECREATION AND PARKS (3) Special problems of recreation and park departments; legal powers and liability; departmental organization, financing, personnel policies, and staff development. Prerequisite: Rc.Pk. 465.

595. PHILOSOPHICAL AND SOCIAL BASES OF RECREATION (3) Philosophical and social bases of recreation; analysis of critical issues of recreation for philosophical and social implications.

REGIONAL PLANNING (R PL)

HARRY S. COBLENTZ, *Chairman, Graduate Program in Regional Planning*
213 Willard Building

FRANCIS FERGUSON, *Program Head for Regional Planning at the Capitol Campus*

Degree Conferred: M.R.P.

Graduate Faculty: Senior Members Buck, Coyle, Gamble, Larson, Lee, and Newman.
Graduate Faculty: Associate Members Christiansen, Coblentz, Griffin, and Miller.

The objective of this interdisciplinary program is to train professional planners who will be aware of the needs of citizens so that they can develop programs for sound social, political, economic, and cultural advancement through the enlightened management of all resources. Programs are offered at University Park and at the Capitol Campus in Middletown. For admission a student should have had at least one course each in sociology, political science, economics, and statistics and at least one course each in any two of the following subjects: geography, cartography, and public administration. Applicants should submit scores on the Graduate Record Examination. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered up to the number of spaces available. Exceptions to the 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

REGIONAL PLANNING (R PL)

400. PRINCIPLES OF REGIONAL PLANNING (3-6)
410. PLANNING PROGRAMS (3)
420. THEORY AND METHODOLOGY OF REGIONAL PLANNING (3)
440. PROBLEMS IN COMMUNITY AND REGIONAL PLANNING (1-9)

502. REGIONAL SYSTEMS ANALYSIS (3-6) Spatial structure of regional and interregional systems. Theories of regional development. Spatial measures of location, density, central tendency and dispersion.

510. PLANNING TECHNIQUES AND ANALYSIS I (3) Regional socioeconomic structure, problems, and factors in planning; data collection, analysis, and implications.

520. PLANNING TECHNIQUES AND ANALYSIS II (3) Interaction of man and environment; land and water resources in regional planning; environmental factors as planning parameters.

530. PLANNING TECHNIQUES AND ANALYSIS III (3) Effects of political, cultural, and physical factors on planning.

540. PROBLEMS IN REGIONAL PLANNING (1-9) Planned individual projects involving library, laboratory (studio), or field work.

RELIGIOUS STUDIES (RL ST)

LUTHER H. HARSHBARGER, *Head of the Department*
1017 Liberal Arts Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Cherry, Fukuyama, Harland, Harrison, and Harshbarger.
Graduate Faculty: Associate Members Vastyan and Whitney.

The emphasis of this program is on the comprehensive understanding of the various facets of religion in American culture, using a variety of methods of analysis and interpretation. A broad cross-disciplinary scope is encouraged in substantive areas with particular emphasis on the development of religious thought and movements and the relationships between religion and society. The student will assume the initiative and major responsibility for shaping his own program with a minimum of formal requirements under the supervision of faculty advisers. He can fulfill the degree requirements by working within the department as well as in cooperation with several other departments with offerings related to the general focus of the program.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by an intermediate knowledge of two foreign languages, by substitution of courses from other designated areas for one of these languages, or by a comprehensive knowledge of one foreign language.

Applications will be evaluated on the basis of the quality of undergraduate, graduate, or professional records, whichever is most appropriate, and on the basis of the candidate's clarity of understanding and interest in the specific emphases of the program as described above. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Graduate Record Examination scores, letters of recommendation, and a statement of the applicant's career goals and academic interests will be required.

RELIGIOUS STUDIES (RL ST)

402. SEMINAR IN CONTEMPORARY RELIGIOUS THOUGHT (3-6)
408. HINDUISM (3)
409. BUDDHISM (3)
421. CULTURE AND RELIGIOUS REFORM (3)
422. RELIGION AND AMERICAN CULTURE (3-6)
430. RELIGION AND MORALITY (3)
438. (Soc. 438) RELIGION AND URBAN SOCIETY (3)
440. PROBLEMS IN RELIGION (3-6)
446. (L.Ed. 446) WESTERN RELIGIOUS LITERATURE FOR SECONDARY SCHOOL TEACHERS (3)
447. (L.Ed. 447) EASTERN RELIGIOUS LITERATURE FOR SECONDARY SCHOOL TEACHERS (3)
461. (Soc. 461) SOCIOLOGY OF RELIGION (3)

500. THEORIES OF RELIGION (3-6) Cross-disciplinary study of two or more systematic theories of religion: anthropological, phenomenological, philosophical, psychological, sociological, or theological.

502. STUDIES IN COMPARATIVE RELIGIONS (3-6) Cross-cultural comparative studies of two or more world religions.

505. SEMINAR IN ASIAN RELIGIONS (3-6) Studies in selected Asian religions.

521. ISSUES IN WESTERN RELIGION (3-6) Seminar. Study of selected issues in Western religion.

522. ADVANCED STUDIES IN AMERICAN RELIGION (3-6) Depth inquiry into either a period, a movement, or a topic of American religion.

524. MAJOR WESTERN RELIGIOUS THINKERS (3-6) Systematic inquiry into the religious thought of major Western religious thinkers.

530. RELIGION AND SOCIETY (3-6) Studies of mutual influences and effects of religion and secular phenomena.

532. RELIGION AND SOCIAL PROBLEMS (3-6) Study of a selected social issue, or constellation of issues, with analysis of its religious and normative dimensions.

536. RELIGIOUS STRUCTURES AND PROCESSES (3-6) Study of the relationship between religion as social structure and as a dynamic social function.

539. ADVANCED STUDIES IN RELIGIOUS ETHICS (3-6) A systematic study of the structure and essential themes of ethics of religious institutions and thinkers.

RURAL SOCIOLOGY (R SOC)

LEE M. DAY, *Head of the Department of Agricultural Economics and Rural Sociology*
6A Weaver Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members Bealer, Brown, Smith, and Willits.
Graduate Faculty: Associate Member Warland.

In all degree programs emphasis is on a comprehensive understanding of the various facets of societal organization pertinent to the rural sector. While scope is encouraged, there are available certain areas of special interest and research: consumer behavior, instigated social change, community structure, human resource development, migration, adolescent behavior, the culture of poverty, and the ecology of rurality in industrialized and urbanized society. All students are required to have training in sociological theory, statistics, and research methods.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by either (1) mastering one foreign language or (2) passing three graduate courses outside the major and minor fields having communications value.

The entering student in the master's program should have as prerequisites 3 credits in rural sociology, 3 credits in sociology, and 3 additional credits in either field. If he does not have these prerequisites, he may take them at the University during the early part of his master's program.

Students with a 2.75 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.75 grade-point average may be made for students with special backgrounds, abilities, and interests.

RURAL SOCIOLOGY (R SOC)

401. SPECIAL TOPICS IN RURAL SOCIOLOGY (1-6)
402. CONSUMER BEHAVIOR AND THE AGRICULTURAL INDUSTRY (3) *Mr. Herrmann*
405. LEADERSHIP FOR SOCIAL CHANGE (3) *Mr. Smith*
425. POVERTY ANALYSIS: PEOPLE AND PROGRAMS (3) *Messrs. Madden and Smith*
444. THE RURAL TRANSITION IN AMERICAN SOCIETY (3) *Mr. Leadley*
452. RURAL ORGANIZATION (3) *Mr. Wilkinson*
456. RURAL COMMUNITY SERVICES (3)
459. RURAL SOCIAL PSYCHOLOGY (3) *Mrs. Willits*

501. DEVELOPMENT OF RURAL SOCIOLOGY (2) Historical development with emphasis on American rural sociology.

502. ADVANCED RURAL SOCIOLOGY (3) Structure and functioning of rural society; evaluation of theoretical systems.

510. Rural Migration (2) Rural migration research and theory; application to governmental and community problems.

513. Sociology of Consumer Behavior (2) Sociological theory and research pertaining to consumer behavior.

514. Values in Rural Society (2) Values as dynamic forces in rural society.

515. Extension Organization and Methods (2) Agricultural and home economics extension as a social system, with emphasis on techniques of organization and program development.

516. Change in Rural Society (2) Social change in rural society, emphasizing prediction and control of the change process.

551. Rural Sociology Seminar (1-6) Prerequisite: 6 credits in rural sociology, sociology, or psychology.

SANITARY ENGINEERING (S E)

Raymond E. Untrauer, *Head of the Department of Civil Engineering*
212 Sackett Building

Degrees Conferred: M.S., M.Eng.

Graduate Faculty: Senior Members McDonnell, Nesbitt, and Unz.
Graduate Faculty: Associate Members Long, Rachford, and Regan.

The entering student normally should be a graduate in engineering from an accredited college of engineering. A student wishing to obtain a Ph.D. degree may major in civil engineering with emphasis on sanitary engineering.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

The following courses offered by the Department of Civil Engineering are appropriate for students majoring in sanitary engineering (course descriptions are given under Civil Engineering): C.E. 451, 452, 462, 465, 471, 472, 476, 551, 553, 564, 571, 572, 573, 574, 575, 576, 577, 579, and 580. Appropriate courses offered by other departments include: Ag. 400; Ag.Ec. 422, 505; Bioch. 401, 402, 425; Biol. 410; Chem. 405; Cmp.Sc. 402; Geol. 452; I.E. 405, 509, 510; M.E. 405, 470, 506, 521, 571; Meteo. 473, 502; Micrb. 400, 417; Nuc.E. 420; Pl.Sc. 419, 578; P.Path. 424; R.Pl. 400, 410, 510, 520.

SCHOOL PSYCHOLOGY (S PSY)

Joseph L. French, *Chairman of the Committee on School Psychology*
102 Cedar Building

Degrees Conferred: D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members French, Gorlow, Noble, Rabinowitz, and Sabatino.
Graduate Faculty: Associate Members Snyder and Ysseldyke.

This intercollege program is based on courses in the Departments of Psychology, Educational Psychology, and Special Education (developmental and remedial reading, speech pathology and audiology, and education of exceptional children). Courses may also be drawn from Individual and Family Studies, Counselor Education, Sociology, Cultural Foundations of Education, Educational Administration, and Academic Curriculum and Instruction.

The objective is to develop a psychologist who is interested in and knowledgeable about education and psychology in the school setting. The school psychologist must utilize his professional skills and his knowledge about children and youth to make contributions which are meaningful to and utilized by teachers, other school personnel, and parents. The development of competences needed by a fully qualified school psychologist requires at least the education represented by a doctoral degree. Only those students who anticipate a doctoral degree will be admitted. Exceptions may be made for students with special backgrounds, abilities, and interests. Students are selected within the limitations of departmental facilities. Priority is given to applicants with work experience with children.

An undergraduate major emphasizing work in psychology and/or education is preferred, but students with fewer than 15 upper-division credits in psychology, educational psychology, or special education may be admitted with limited deficiencies to be fulfilled concurrently with their graduate work. Requirements for admission include a minimum junior-senior scholastic average of 2.85 or, for applicants with master's degrees, a minimum of one-third of graduate credits of "A" quality; satisfactory recommendations from two or more professors, preferably psychologists; and 500 or higher on the general sections of the Graduate Record Examination, 58 or higher on the Miller Analogies Test, and/or 35 or higher on the Quantitative Evaluative Device.

Practicum facilities include The Center for Educational Diagnosis and Remediation, the School Psychology Clinic, the Speech Pathology and Audiology Clinic, the Reading Center, the Psychology Clinic, the Campus Demonstration School for handicapped children, and those in nearby public schools. Facilities for work with children are also available through other departments, as well as through assistantship assignments.

Although additional courses from the supporting and other departments are utilized in doctoral programs, core courses from which school psychology students build a program for the school psychologist certificate issued by the Pennsylvania Department of Education are: C.F.Ed. 515; Cn.Ed. 403, 501, 503, 508, 592; D.R.R. 441, 444, 545; Ed.Adm. 480, 576; Ed.Psy. 400, 406, 421, 450, 475, 506, 512, 513, 522, 523, 524; E.E.C. 400, 401, 403, 410, 420, 430, 454, 470, 480, 501, 554; Psy. 404, 412, 417, 418, 425, 426, 541, 542, 555, 558, 559, 561; S.P.A. 440.

SCHOOL PSYCHOLOGY (S PSY)

500. Professional Issues in School Psychology (1-3) Orientation to the field through study of unique problems, current issues, ethical and legal matters, unique cases, and research projects.

504. Practicum in School Psychology (1-6) Clinical experience with children under supervision in a variety of settings requiring service including practice in synthesizing data and observations.

508. Internship in School Psychology (1-10) Long-term placement in settings providing work for school psychologists with children, parents, teachers, administrators, and service agencies under supervision.

510. Supervision of School Psychologists (1-10) Program supervision and professional leadership in University clinics and school systems. Prerequisite: S.Psy. 504.

559. (Psy. 559) The Individual Psychological Examination (3) Demonstrations and practice in widely used ability and aptitude tests; psychological report writing. Prerequisites: 15 credits in psychology and a course in measurement.

SECONDARY EDUCATION (SECED)

DONALD R. CHIPLEY, *In Charge of Graduate Programs in Secondary Education*
159 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Fagan, Fowler, Golub, Greenhill, Heimer, Searles, and Withall.
Graduate Faculty: Associate Members Bell, Dupuis, Jansson, Johnson, Kozak, Miller, Szabo, and Welliver.

Graduate degree programs emphasize the advanced preparation of classroom teachers, special supervisory personnel, and curriculum specialists. Candidates for the D.Ed. and Ph.D. degrees with a major in secondary education must meet all the requirements, including residence, described in the earlier sections of this bulletin.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign languages.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. Also required is a provisional certificate to teach in secondary schools and two letters of recommendation. For admission to the D.Ed. program at least 18 credits in education and related psychology are required.

Candidates for the D.Ed. degree with a minor in secondary education must take a minimum of 15 course credits approved in advance by the person in charge of the major in secondary education. When course work has been completed more than five years prior to admission to the D.Ed. or when it is transferred from another institution, the chairman of the graduate faculty will determine its suitability for any part or all of the 15 hours required.

Candidates for the M.S. degree with a major in secondary education will fulfill all the requirements for that degree, including a thesis, which are listed previously in this bulletin. Candidates with a minor in secondary education must have 6 credits in education approved by the chairman of the graduate faculty. In general, candidates for the M.Ed. in secondary education must have 18 approved undergraduate credits in education and psychology including practice teaching in an area appropriate to the major, and aptitude for and interest in advanced professional preparation. Applicants are urged to have had at least two years of successful teaching experience before completion of the degree requirements. Although candidates are required to specialize in secondary education, they are encouraged to increase their general education in the social sciences, the behavioral sciences, and the humanistic foundations.

The M.Ed. degree may be earned in those fields outside of secondary education for which a master's degree has been approved, provided such a professional program is appropriate. For example, the M.Ed. degree may be earned with a major in English or geography. These programs require 6 credits in professional education approved in advance by the head of the department or the person responsible for the minor field chosen, e.g., secondary education, agricultural education, etc.

A candidate for an advanced degree in this major should check with his program adviser for courses which are applicable to a specific degree from those listed on pages 81-82 in this bulletin.

SLAVIC LANGUAGES AND LITERATURES (S L L)

WILLIAM R. SCHMALSTIEG, *Head of the Department of Slavic Languages*
N-440 Burrowes Building

Degree Conferred: M.A.

Graduate Faculty: Senior Members Birkenmayer, Magner, Marvan, and Schmalstieg.
Graduate Faculty: Associate Member Paternost.

Opportunities for specialization in literature or linguistics are available. A minimum requirement for admission is an undergraduate major in Russian or its equivalent.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

The department prefers that M.A. candidates in this major submit a term paper rather than a thesis.

RUSSIAN (RUS)

426. DOSTOEVSKY (3)
427. TOLSTOY (3)
430. METHODS AND MATERIALS FOR TEACHING RUSSIAN (3)
450. HISTORY OF THE RUSSIAN LANGUAGE (3)
460. LINGUISTIC ANALYSIS OF CONTEMPORARY RUSSIAN (3)
497. PROBLEMS IN RUSSIAN (3-9)

*1G. TECHNICAL RUSSIAN FOR GRADUATE STUDENTS (3) Prepares student to translate technical and scientific texts. No previous knowledge of Russian is required.

*2G. RUSSIAN TEXTS (3) Development of skill in translating Russian texts in the sciences and social sciences. Prerequisite: Rus. 5 or 1G.

501. READINGS IN RUSSIAN LITERATURE (3-6) Prerequisite: Rus. 204.

525. PUSHKIN (3) Pushkin's significance in Russian literature; his relation to other European literatures; *Eugene Onegin* and selected shorter works.

540. SEMINAR IN OLD RUSSIAN LITERATURE (3) Literary and linguistic analysis of Russian literary monuments in the original, 1100-1800. Prerequisite: Rus. 450.

542. SEMINAR IN SOVIET LITERATURE (3-6) Works of representative Soviet writers; individual research in contemporary Soviet literature and literary criticism.

570. SEMINAR IN THE ANALYSIS OF OLD RUSSIAN LITERARY DOCUMENTS (3-6) Reading, translation, interpretation, and analysis of old Russian literary documents. Texts differ from those read in Rus. 540. Prerequisite: Slav. 550.

SLAVIC (SLAV)

500. BIBLIOGRAPHY AND RESEARCH TECHNIQUES (3) Tools and methods of research, designed for students preparing to do independent investigation of problems in Slavic languages and literatures.

510. STRUCTURE OF THE SOUTH SLAVIC AND WEST SLAVIC LANGUAGES (3-12; 3 credits per language) Linguistic analysis of a particular South Slavic (Bulgarian, Macedonian, Serbo-Croatian, Slovenian) or West Slavic (Czech, Lusatian, Polish, Slovak) language. Prerequisite: Rus. 460 or one graduate course in linguistics.

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*No graduate credit is given for this course.

550. OLD CHURCH SLAVIC (3) Reading and study of that corpus of religious and liturgical documents representing the first written records of a Slavic tongue.

560. THEORY AND TECHNIQUE IN SLAVIC LINGUISTICS (3-6) Analysis of the relationship of the Slavic languages; consideration of particular linguistic problems within one or more of the languages.

SOCIAL STUDIES (SO ST)

HUGO A. MEIER, *Chairman of the Committee on Social Studies*
612 Liberal Arts Building

Degree Conferred: M.Ed.

This program, designed to meet the needs of secondary school teachers, requires at least 24 credits chosen from economics, history, human geography, political science, and sociology. A candidate is expected to complete at least 3 credits each in four of these areas but not more than 12 in any one of them. A minor of at least 6 credits in educational foundations is also required.

For admission a student must have had solid preparation in the basic courses in economics, history, political science, and sociology and should have had some advanced undergraduate work in at least one of these areas. He must also have had 18 credits in education and related psychology, and he should be certified for teaching social studies. Ideally, he should have had teaching experience in this field as well.

Students who present a 2.50 junior-senior average and a 3.00 average in the social studies areas will be considered for admission. The best qualified applicants will be accepted up to the number of places that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

SOCIOLOGY (SOC)

ROLAND J. PELLEGRIN, *Head of the Department*
201B Liberal Arts Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Buck, Clark, DeJong, Faulkner, Matson, Simirenko, Snyder, and Theodorson.
Graduate Faculty: Associate Members Foreman, Raphael, Rath, Sim, and Westby.

The M.A. and Ph.D. programs center around a training in basic social theory and methodology and the empirical findings in the various areas of sociology. Departmental emphases include social psychology, sociological theory, social gerontology, community structure and change, and an interdisciplinary program in population issues. Other areas in which it is possible for students to specialize include complex organizations, political sociology, the sociology of education, the sociology of religion, the family, and methodology and statistics. The program is designed with considerable flexibility so that students can adapt course work outside the department to their individual interests and goals. Work in computer science, philosophy of science, or mathematics may be used to fulfill part of the Ph.D. degree communication and foreign language requirement, but a reading knowledge of a minimum of one foreign language is required. All first-year students who intend to pursue doctoral work are expected to earn an M.A. degree in their normal progress to the Ph.D. The department offers three options leading to the M.A. degree. The choice of program option will be determined by agreement between the student and his adviser. A student has the option to write a thesis or a paper for the M.A. degree.

Undergraduate training in sociology is expected. Students of ability who are deficient in undergraduate preparation may be accepted with provisions to make up course deficiencies in the early part of their graduate program. Candidate selection is based on the following information: quality undergraduate academic performance, above average Graduate Record Examination scores, letters of recommendation, an essay giving the applicant's interests, goals, and purposes for graduate work in sociology, and submission of written work from the student's undergraduate program, such as a term paper. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

The population issues program is a course of study focusing on the social, economic, and geographic policy-related issues arising from the dynamics of population trends, especially in developed nations. In addition to departmental admission requirements, the population issues committee evaluates the student's interest and aptitude for the training program which consists of a minimum of 21 credits of interdisciplinary course work in population.

Other areas of study related to sociology, such as rural sociology, community development, cultural anthropology, developmental psychology, and political behavior are offered in other departments of the University.

Special departmental research and training facilities include The Liberal Arts Data Laboratory, small groups research laboratory, and a sociology reference library. Additional University facilities used by sociology faculty and graduate students include the Computation Center, the Inter-University Consortium of Political Research, the Institute of Public Administration, the Institute for Research in Human Resources, and the Center for the Study of Religion and Human Resources.

SOCIOLOGY (SOC)

400. Advanced General Sociology (3)
401. Social Institutions (3)
403. Advanced Social Psychology (3)
404. Small Groups (3)
406. Sociological Analysis of Deviance (3)
408. Social Ecology (3)
410. Social Psychology of Health (3)
412. Penology (3)
413. Methods and Techniques of Social Research (3)
415. The Urban Community (3)
416. (C.F.Ed. 416) Sociology of Education (3)
418. The Development of Social Thought (3)
419. Race Relations (3)
422. History of Sociological Theory (3)
423. Social Demography (3)
424. Social Change (3)
426. Public Welfare Policy and Services (3)
427. Social Case Work (3)
428. Seminar in Sociology (1-6)
429. Social Stratification (3)
430. Family in Cross-Cultural Perspective (3)
432. Collective Behavior (3)
435. Social Gerontology (3)
436. (Journ. 436) Sociology of Opinion Formation (3)
438. (Rl.St. 438) Religion and Urban Society (3)
444. Complex Organizations (3)
446. Political Sociology (3)
450. Community Organization (3)
453. (Anthy. 453) Primitive Religion (3)

454. (L.S. 454) Industry and the Community (3)
455. (L.S. 455) Occupations and Professions (3)
456. Readings in Sociology (1-9)
457. (L.S. 457) Field Work in Industrial Sociology (1-6)
461. (Rl.St. 461) Sociology of Religion (3)
470. Intermediate Social Statistics (4)
473. Methods of Demographic Analysis (3-6)
499. Foreign Study in Sociology (2-6)

500. Seminar in Group Theory (1-3) The group as a unit of social structure and action.

502. Theories of Society (3) Past and present theories of the overall structure and processes of societal functioning.

503. Research Seminar in Social Psychology (3-6) Design and conduct of research in areas of mutual interest in social psychology.

504-505. Current Social Theory (3 each) Current contributions to social theory; their relations to each other and to the larger theoretical structure.

506. Seminar in Sociological Theory (3-9)

507. Introduction to Graduate Study in Sociology (1) Required of all incoming graduate students in sociology.

509. Seminar in Medical Sociology Research (1-6) Early and current classics of medical sociology research critically reviewed; limitations and possibilities; needs of society; available resources. Prerequisites: Soc. 410, 413.

510. Field Work in Sociology (1-6)

511. Readings in the Sociology of Health (1-6) Independent pursuit of existing knowledge in fields of the student's interest, in reference books, monographs, journals. Bibliography preparation. Prerequisite: Soc. 410.

512. Seminar in Deviant Behavior (2-6) Advanced sociological study of crime, juvenile delinquency, mental disorders, suicide, drug addiction, prostitution, and other social deviation. Prerequisite: 6 credits in sociology.

513-514. Sociological Methods (3 each) Critical review of methodological issues; philosophy of science; research designs; analysis and interpretation of findings. Prerequisites: Soc. 413, 470.

515. Seminar in Community Studies (3)

518. Research Studies in the Sociology of Education (3) Analyses of the design, methods, and findings of selected classical and current research studies in the sociology of education. Prerequisite: Soc. 416.

523. Seminar in Population Theory and Policy (1-6) Critical review of multidisciplinary population research with an emphasis on its relation to policy issues. Prerequisite: 3 credits in population or human ecology.

525. Seminar in Sociology (1-6) Research problems in theoretical and applied sociology.

529. Seminar in Intergroup Relations (3) Review of research into minority-majority group relations.

530. Research on Marriage and the Family (3) Training in methods and techniques of research in family relations. Experimental, statistical, and comparative studies are carried out, individually or cooperatively. Prerequisite: 3 credits of previous work in this field.

532-533-534. Social Relations (3 each) Critical appraisal of major social-psychological problems confronting modern man; emphasis on formulation of fruitful research projects and their evaluation. Prerequisite: 15 graduate credits in social science departments or psychology, including a course in statistics.

535. Seminar in Gerontology (2-6) A structural-functional analysis of current research dealing with the relationships between institutional structure, age grading, and social behavior.

*546. SEMINAR IN POLITICAL SOCIOLOGY (3-6) Research and analysis of contemporary issues in political sociology. Prerequisite: 3 credits in statistics.

555. INDUSTRIAL SOCIOLOGY (3) Research methods and techniques in industrial sociology; current research, unexplored areas.

572-573. SOCIAL STATISTICS (3 each) Application of parametric and non-parametric statistical methods to sociology; sampling; computer data processing techniques. Prerequisites: Soc. 470 and 3 credits in research methods.

574-575. QUANTITATIVE SOCIOLOGY (3 each) Problems and issues in the mathematical and quantitative aspects of sociology. Prerequisites: Soc. 413, 470.

SOLID STATE SCIENCE (S S S)

ROBERT E. NEWNHAM, *In Charge of Graduate Programs in Solid State Science*
139 Materials Research Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Barsch, Cross, Dachille, Henisch, Kline, Knox, McKinstry, Mulay, Newnham, D. Roy, R. Roy, Stubican, Vastola, Vedam, Walker, E. White, and W. White.
Graduate Faculty: Associate Members Johnson, McCarthy, Spear, and Thrower.

The aim of this intercollege program is to provide an opportunity for the student interested in the structure, properties, and behavior of solid materials to obtain an integrated program of courses encompassing both the necessary fundamentals of chemistry, physics, and mathematics and their technological and engineering applications.

The program of courses taken by a student majoring in this program must necessarily cut across two or more disciplines. The relevant subject matter has been grouped into four areas: (1) the structure of solids (crystal chemistry and structure determination); (2) theory related to the solid state (physics, chemistry, and mechanics); (3) properties of solids (optical, electrical, magnetic, mechanical, thermal, and chemical); and (4) reactions of solids (phase equilibria, reaction mechanisms, reaction kinetics, and surface reactions).

The course work of all students will normally include the "core program" as periodically redefined by the committee. Recommended course sequences for each year for students with different undergraduate backgrounds are prepared by the chairman and are available from the student's adviser. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages or by one foreign language together with courses from other designated areas.

Entering students should hold a bachelor's degree in chemistry, physics, mathematics, geological science, engineering, ceramics, or metallurgy, or in a closely related field that will have included in it mathematics at least through integral calculus and a minimum of one year of physics and one year of chemistry. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. The applicant should be interested specifically in an interdisciplinary program of study and research. Thesis research on various aspects of the solid state may be conducted in the Materials Research Laboratory, the Applied Research Laboratory, or in appropriate departments in the Colleges of Earth and Mineral Sciences, Engineering, and Science. The experimental facilities for research in several aspects of materials science and engineering are exceptional.

S.S.S. 590 (colloquim) and S.S.S. 596 (individual studies) will be offered once each year to promote the interdisciplinary aspects of solid state science. Further information will be available from the S.S.S. office.

In addition, students may select appropriate course work from any engineering or science department. The following list includes those which are most commonly taken to satisfy core curriculum requirements: Structure of Solids: Cer.Sc. 508; Mat.Sc. 421, 512, 514. Solid State

*3 credits per term.

Theory: Metal. 508, 509; Phys. 410. Physical Properties of Solids: Mat.Sc. 542; Phys. 412, 413, 524. Chemical Reactions in Solids: G.Chem. 513; Mat.Sc. 416.

SPANISH (SPAN)

MARTIN S. STABB, *Head of the Department of Spanish, Italian, and Portuguese*
N-352 Burrowes Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty: Senior Members Brentin, Dalbor, Lima, Moser, Perez, Stabb, and Sturcken.
Graduate Faculty: Associate Members Halsey, Lyday, Peavler, Ramos, and Triolo.

The minimum requirement for admission will normally be 24 credits of postintermediate work in Spanish language and literature. A student may specialize in either the area of literature or descriptive and historical linguistics. The department may waive the requirement of a thesis for M.A. candidates in this major.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages or by comprehensive knowledge of one.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

SPANISH (SPAN)

400. ADVANCED GRAMMAR AND COMPOSITION (3)
404. THE EVOLUTION OF SPANISH (3)
410. ADVANCED ORAL EXPRESSION AND COMMUNICATION (3)
413. THE TEACHING OF SPANISH (4)
414. SPANISH PHONOLOGY (3)
415. SPANISH MORPHOLOGY AND SYNTAX (3)
416. OLD SPANISH LITERATURE (3)
426. THE GOLDEN AGE (3)
427. DRAMA OF THE GOLDEN AGE (3)
439. DON QUIJOTE (3)
459. THE GENERATION OF 1898 (3)
472. THE CONTEMPORARY SPANISH-AMERICAN NOVEL (3)
475. INTRODUCTION TO LATIN-AMERICAN LITERATURE (3)
476. INTRODUCTION TO LATIN-AMERICAN LITERATURE (3)
477. THE LITERATURE OF MEXICO (3)
480. LITERATURE OF ARGENTINA (3)
482. SPANISH LYRIC POETRY (3)
483. SPANISH DRAMA OF THE NINETEENTH CENTURY (3)
485. SPANISH DRAMA OF THE TWENTIETH CENTURY (3)
487. THE SPANISH NOVEL OF THE NINETEENTH CENTURY (3)
489. THE SPANISH NOVEL OF THE TWENTIETH CENTURY (3)
497. PROBLEMS IN HISPANIC LITERATURE (3-12)
499. FOREIGN STUDY IN SPANISH (3)

502. THEORY AND TECHNIQUES OF TEACHING SPANISH (1-3) Audio-lingual orientation. *Mr. Dalbor*

503. METHODS AND BIBLIOGRAPHY IN SPANISH (1-3) Methods of research; evaluation of sources and materials. *Staff*

505. OLD SPANISH: PHONOLOGY, MORPHOLOGY, AND SYNTAX (3) *Mr. Sturcken*

506. HISTORY OF THE SPANISH LANGUAGE (3) *Mr. Sturcken*

507. HISPANO-ROMANCE LINGUISTICS (3) *Mr. Sturcken*

510. SPANISH DESCRIPTIVE LINGUISTICS: PHONOLOGY (3) *Mr. Dalbor*

511. SPANISH TRANSFORMATIONAL-GENERATIVE LINGUISTICS (3) *Mr. Dalbor*

514. HISPANIC DIALECTOLOGY (3) Early fragmentation among the peninsular dialects; origins and descriptive analysis of the American dialects; Judeo-Spanish. *Messrs. Sturcken and Dalbor*

515. MEDIEVAL SPANISH NONEPIC LITERATURE (3) *Mr. Sturcken*

516. MEDIEVAL SPANISH EPIC POETRY AND PROSE (3) The *Poema de Mio Cid;* origins and diffusion of epic themes; their influence through the *crónicas,* the *Romancero,* and later literature. *Messrs. Sturcken and Triolo*

518. EL LIBRO DE BUEN AMOR (3) *Mr. Sturcken*

521. THE CELESTINA AND THE LITERATURE OF THE SPANISH PRE-RENAISSANCE (3) Chief trends and works of the period of the Catholic Monarchs with special emphasis on Fernando de Rojas' masterpiece *La Celestina. Messrs. Triolo and Pérez*

525. SPANISH RENAISSANCE AND GOLDEN AGE POETRY (3) Lyric poetry, epic poetry, and balladry. *Mr. Triolo*

527. SIXTEENTH-CENTURY SPANISH PROSE (3) The major prose writers of the Spanish sixteenth century. *Messrs. Brentin and Pérez*

528. SEVENTEENTH-CENTURY SPANISH PROSE (3) Various types of novels of the seventeenth century, with special emphasis on the picaresque, didactic literature, histories. *Messrs. Brentin and Pérez*

538. THEATRE OF LOPE DE VEGA AND HIS CYCLE (3) Major works of Lope de Vega, Tirso de Molina, Buillen de Castro, Mira de Amescua, and others. *Mr. Pérez*

539. THEATRE OF CALDERÓN DE LA BARCA AND HIS CYCLE (3) Major works of Calderón de la Barca, Rojas Zorrilla, Augustin Moreto, and others. *Mr. Pérez*

540. CERVANTES: THE QUIJOTE (3) A careful reading of Cervantes' famous novel and consideration of some of the corpus of criticism on the novel. *Messrs. Pérez and Brentin*

541. CERVANTES: OTHER WORKS (3) Cervantes' major works, excluding the *Quijote. Messrs. Brentin and Pérez*

544. SPANISH ROMANTICISM (3) The major authors and works of peninsular romanticism, including poetry, drama and prose. *Miss Halsey and Mr. Lima*

550. SPANISH REALISM (3) The major figures of the period with special emphasis on Pérez Galdós. *Mr. Ramos*

554. GENERATION OF 1898: PROSE (3) Selected essays and novels from the works of Ganivet, Pidal, Unamuno, Maeztu, Azorin, Lanza, Baroja and Valle-Inclán. *Messrs. Lima and Ramos*

555. GENERATION OF 1898: POETRY AND DRAMA (3) Selected poems and plays from the works of Antonio and Manuel Machado, Benavente, Grau, Azorin, Valle-Inclán, Unamuno, Baroja and others. *Mr. Lima*

560. THE CONTEMPORARY NOVEL IN SPAIN (3) The novel since 1941: Cela, Laforet, Zunzunegui, Suárez Carreño, Matute, and others. *Messrs. Brentin and Ramos*

563. CONTEMPORARY DRAMA IN SPAIN (3) The drama since 1898 to the present day: Benavente, Valle-Inclán, Garcia Lorca, Casona, Buero Vallejo, Sastre, and others. *Miss Halsey and Mr. Lima*

566. CONTEMPORARY SPANISH POETRY (3) Various currents in Spanish poetry from the Generation of 1927: Lorca, Aleixandre, Salinas, Guillen, Alonso, Alberti, Hernandez, Otero and others. *Mr. Brentin*

570. MODERNISMO (3) The movement, its antecedents, and its followers, with special emphasis on Rubén Darío. *Mr. Moser*

572. SPANISH-AMERICAN NOVEL OF THE NINETEENTH AND EARLY TWENTIETH CENTURY (3) Evolution of the genre and representative works. *Messrs. Stabb and Lyday*

573. The Contemporary Spanish-American Novel (3) Evolution of the genre since 1940 and representative novelists. *Mr. Stabb*

575. The Spanish-American Essay (3) Tracing the history of ideas in Spanish America through major essayists. *Messrs. Stabb and Moser*

576. Twentieth-Century Spanish-American Poetry (3) Influential poets and literary movements after *Modernismo. Messrs. Lyday and Stabb*

577. Spanish American Drama (3) Dramatic literature in Spanish America from colonial times to the present. *Mr. Lyday*

579. Colonial Literature (3) Transplantation of European culture to Spanish America, literary genres cultivated in the colonies, and principal writers. *Mr. Moser*

581. The Spanish-American Short Story (3) Critical analysis of the major writers and movements from Echeverría to the present. *Messrs. Stabb and Lyday*

584. Spanish American Romanticism (3) The principal writers and tendencies of the Romantic movement in Spanish America. *Mr. Moser*

587. Stylistic and Literary Criticism (3) Major theories of literary criticism applied to Hispanic literature. *Staff*

588. Seminar in Hispanic Literature (3-12) Common and individual research in special problems in Spanish or Spanish-American literature. *Staff*

SPEECH (SPCH)

Herman Cohen, *Head of the Department*
212 Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.A.

Graduate Faculty: Senior Members Arnold, Borden, Brubaker, Cohen, Fife, Frandsen, Gregg, Holtzman, Nelson, Paulson, Phillips, and White.
Graduate Faculty: Associate Members Benson, Butt, Dunham, Hauser, and Preston.

The student may specialize in speech arts (interpretation, drama, theatre); radio and television; rhetoric and public address (including discussion, communication, teaching of speech); speech science (voice, diction, phonetics, general semantics); communicative theory; or international communication. A thesis is required of all M.A. candidates in this major.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign languages.

The minimum undergraduate preparation required is 12 credits in speech. Students who cannot meet this requirement in full may be admitted but must make up their deficiencies without credit toward the graduate degree. Spch. 400 and 502 are required of all graduate students who do not have their equivalents.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

SPEECH (SPCH)

400. Teaching of Speech (3) *Mr. Butt*
402. Speech and Human Behavior (3) *Mr. Phillips*
403. Interpersonal Oral Communication Theory (3)
410. English Phonetics and Pronunciation (3) *Mr. Brubaker*
412. Speech Criticism (3) *Mr. Arnold*
413. (Ling. 413) Experimental Linguistics (3)
417. Directing Forensics (3) *Mrs. Lutz*

419. (Journ. 419) Comparative Broadcasting Systems (3)
420. History of Rhetorics (3)
425. Radio Programming and Performance (3) *Miss Preston*
431. Anatomy and Physiology of the Ear and Vocal Mechanisms (3) *Messrs. Brubaker and Gilbert*
435. Radio and Television Programming (3) *Mr. Nelson*
437. Television Programming and Performance (3) *Staff*
440. Speech-Communication: Research and Theory (3) *Mr. Frandsen*
450. Discussion: Research and Theory (2-6) *Messrs. Butt and Phillips*
470. Nonverbal Communication (3) *Messrs. Benson and Frandsen*
475. Studies in Mass Persuasion in the Democratic Society (3) *Messrs. Gregg and Hager*
478. Contemporary Public Address: English and American Speakers (2) *Mr. Gregg*
480. Computer Applications in Speech Studies (3) *Mr. Borden*
485. Advanced Oral Interpretation of Literature (3) *Mr. Wigley*
489. Directed Study (1-6) *Staff*
490. Psychology of Speaking and Listening (3) *Mr. Holtzman*
494. Teaching of English as a Second Language (3) *Mr. Holtzman*
496. Speech for Teachers (3) *Mr. Butt*

500. Seminar in American Oratory (2-6) History of American oratory with application of critical standards to the work of specific orators. *Mr. White*

502. Research Methods in Speech (3) Research design, thesis proposals, and background for research in graduate study. Prerequisite: 6 credits at the 400 or 500 level in speech, clinical speech, or theatre arts. *Staff*

505. Historical Development of Speech Theory and Criticism (2-4) Classical theories of speech making from the earliest beginnings to the fall of the Roman Empire. *Mr. Arnold*

506. Historical Development of Speech Theory and Criticism (2-4) Theories of speech making from the Renaissance to the present. *Mr. Arnold*

507. Contemporary Rhetorical Theory (2-4) A study of rhetorical theory from 1930 to the present, focusing on semantic, political, sociological, symbolic, and philosophical perspectives. Prerequisites: Spch. 412, 505 and/or 506. *Mr. Gregg*

508. Seminar in British Oratory (2-4) History of British oratory; application of critical standards to the work of selected orators. *Miss Fife*

509. Problems in Rhetoric and Oratory (2-6) Comparative study of selected orators and rhetoricians. Prerequisite: 6 credits in speech. *Staff*

510. Problems in Speech Education (2-4) Advanced knowledge, theories, and principles, together with their philosophical, scientific, clinical, artistic, and educational implications for the teacher of speech. Prerequisite: Spch. 502 and 9 additional credits at the 400 or 500 level in speech, clinical speech, or theatre arts. *Mr. Phillips*

520. Seminar in Speech Science (3-6) Seminar in physical and physiological bases of speech and voice; introduction to laboratory techniques used in speech research. Prerequisite: 9 credits in speech, speech pathology and audiology, or psychology. *Messrs. Brubaker and Gilbert*

530. Political Speaking in the Broadcast Media (3) Study and research of the principles of speaking as they are employed for political purposes when utilizing the broadcast media. *Mr. Nelson*

540. Seminar in Problems of Television and Radio (2-4) Study and research in television and radio as they pertain to programming, production, relation to society, and speech. *Mr. Nelson*

550. Seminar in Oral Persuasion (2-4) Theory and devices of persuasion; analysis of persuasive discourse. Prerequisite: 6 credits in speech including Spch. 200. *Messrs. Holtzman and Frandsen*

552. Oral Communication in Industry, Business, and Government (2-4) Needs, practices, and methods in American industry, business, and government; methods of training adults in oral communications skills. *Mr. Frandsen*

554. SEMINAR IN SMALL GROUP COMMUNICATION (2-4) Communication variables in small groups. Experimental research and innovations in communication in vocational, therapeutic, and educational groups. *Mr. Phillips*

555. SPEECH COMMUNICATION: PROBLEMS AND PRINCIPLES (2-6) Prevalent theories of speech influence. *Messrs. Borden, Phillips, and Frandsen*

564. SEMINAR IN EUROPEAN ORATORY (2-4) Analysis of significant European speeches with consideration of cultural influences on invention and style. Prerequisite: 6 credits in speech. *Staff*

575. RESEARCH PROBLEMS IN SPEECH (1-9) Advanced research on an individual basis in oratorical criticism, discussion techniques, persuasion, pedagogy, phonetics, speech science, and speech pathology. Prerequisite: 12 credits in speech or speech pathology and audiology. *Staff*

SPEECH PATHOLOGY AND AUDIOLOGY (S P A)

BRUCE M. SIEGENTHALER, *In Charge of Graduate Programs in Speech Pathology and Audiology*
110 Moore Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Frick, McDonald, Michael, and Siegenthaler.
Graduate Faculty: Associate Member Berlin.

Students may specialize in speech pathology, audiology, or education of the hearing impaired. The programs include the requirement of a number of field trips to diagnostic and treatment facilities and may include a period of internship at an off-campus location. Students should expect to have moderate expenses related to these trips.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign languages. The nonthesis option is available for the M.S. degree.

Approximately 40 credits are required, distributed among speech pathology, audiology, education of the deaf, speech science, education and psychology, and including a course in statistics. Students entering without an undergraduate program in the field may be required to take additional make-up work. The admission application for each student is reviewed, and he is advised regarding admission requirements.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

SPEECH PATHOLOGY AND AUDIOLOGY (S P A)

430. INTRODUCTION TO AUDIOLOGY (3)
433. VISUAL SPEECH RECEPTION AND AUDITORY TRAINING (3)
434. PURE TONE AUDIOMETRY (3)
439. PRACTICUM IN AUDITORY TRAINING AND SPEECH READING (1-5)
440. (E.E.C. 440) SURVEY OF SPEECH AND HEARING DISORDERS (3)
441. CURRENT PROBLEMS IN SPEECH PATHOLOGY AND AUDIOLOGY (1-6)
442. SPEECH PATHOLOGY: ARTICULATION AND STUTTERING (3)
444. SPEECH PATHOLOGY: VOICE AND ORGANIC DISORDERS (3)
445. PROFESSIONAL PROGRAMS AND RELATIONSHIPS (3)
449. PRACTICUM IN SPEECH THERAPY (1-6)
459. PRINCIPLES OF CLINICAL MANAGEMENT IN S.P.A. (2)
460. COMMUNICATION SKILLS FOR HEARING IMPAIRED I (2)
461. COMMUNICATION SKILLS FOR HEARING IMPAIRED II (3)
462. CLINICAL BASES OF LANGUAGE DISORDERS (2)

463. Teaching Language to the Hearing Impaired (3)
464-465. Teaching Elementary School Subjects to the Deaf (2 each)
467. Audiology for Teachers of the Deaf (3)
469. Student Teaching with the Deaf (3-12)

530. Seminar in Audiology (1-6) Review of theories of hearing and review of related physiological and psychological researches. Prerequisite: S.P.A. 434.

531. Speech Audiometry and Hearing Aids (3) Techniques and interpretation of speech reception tests; hearing aids and hearing aid advisement procedures; observations and practice in test administration. Prerequisite: S.P.A. 434.

532. Acoustical Instruments for Hearing (3) Acoustical instrumentation used for research in hearing, programs of hearing conservation, and noise control, including clinical and industrial applications. Prerequisite: 6 credits in acoustics, audiology, experimental psychology, or speech science at 400 level.

534. Noise and Hearing (3) Noise induced hearing problems; interference with communication; annoyance and community problems caused by acoustic energy; regulations and standards. Prerequisite: 6 credits at 400 level in acoustics, audiology, experimental psychology, or speech science.

538. Practicum in Audiologic Evaluation and Selection of Hearing Aids (1-5) Prerequisite: S.P.A. 531.

540. Articulation Disabilities (3) Speech-sound production disorders in children and adults; methods of examination, diagnosis, and treatment. Prerequisites: S.P.A. 442, 449.

541. The Voice and Its Disorders (3) Physical, physiological, and psychological bases of voice production; causes, nature, and symptoms of its disorders; current clinical methods in voice improvement. Prerequisites: S.P.A. 444, 449.

542. Stuttering (3) Modern theories of causes of disorders of rhythm; methods of examination, diagnosis, and treatment. Prerequisites: S.P.A. 442, 449.

543. Diagnostic Procedures in Clinical Speech (3) Clinical instrumentation; case history taking; examination procedures and materials used in diagnosing speech disabilities; interpretation of findings; report preparation. Prerequisite: S.P.A. 444.

544. Cleft Palate (3) Anatomy, physiology, embryology, and growth of the palate and contiguous structures; etiology, diagnosis, habilitation of cleft palate problems. Prerequisite: S.P.A. 444.

545. (E.E.C. 545) Cerebral Palsy (3) Etiology and symptomatology of cerebral palsies; diagnosis and treatment of communication problems; the multiprofessional habilitative program. Prerequisite: S.P.A. 444.

546. Language Disorders in Adults (3) Nature, etiology, diagnosis, and management of language disorders in adults. Prerequisite: 9 credits S.P.A. or related fields such as psychology, linguistics, or human development.

547. (E.E.C. 547) Language Disorders in Children (2) Nature, etiology, diagnosis, and management of language disorders in children. Prerequisite: 9 credits in speech pathology and audiology or related fields such as psychology, linguistics, or human development.

548. Practicum in Speech Diagnosis (1-3) Supervised practice in interviewing, counseling, speech evaluation, and synthesis of psychological medical and audiological data in speech diagnosis; report writing. Prerequisites: S.P.A. 444, 449.

549. Advanced Practicum in Speech Therapy (1-6) Theoretical and clinical rationale of therapy; professional role and relationships; therapy procedures, individual and group; evaluation of process and outcomes. Prerequisites: S.P.A. 442, 449.

550. Seminar in Speech Pathology (1-6) Advanced study of special problems and new developments in speech pathology. Prerequisites: S.P.A. 442, 444.

560. Recent Developments in Education of the Deaf (2-6) In-depth seminar style study of communication disorders associated with deafness, and advanced and experimental attempts at remediation. Prerequisites: 8 credits in education of the deaf or audiology, S.P.A. 430 and 433, and 3 credits in child development or learning theory.

STATISTICS (STAT)

William L. Harkness, *Head of the Department*
333 McAllister Building

Degrees Conferred: Ph.D., M.S., M.A.

Graduate Faculty: Senior Members Antle, Bartoo, Haight, Harkness, Hultquist, Joiner, and Patil.
Graduate Faculty: Associate Members Boswell, Hettmansperger, Kappenman, Klimko, and Ryan.

Graduate instruction and research opportunities are available in most areas of probability and statistics, including experimental design, linear models, multivariate analysis, nonparametric statistics, analysis of counted data, computerized data analysis, distribution theory, stochastic processes (applied and theoretical), various areas in probability theory, and statistical ecology.

For the M.A. degree the candidate must complete 30 course credits, with at least 18 credits (12 in statistics) of 500-level courses, 3 credits in computer science, Math. 441 or 481, 3 credits in seminars and/or individual studies, and six courses in an approved area. The degree requirements for the M.S. degree are the same as for the M.A., except 6-9 credits of thesis replace an equal number of course credits.

Ph.D. candidacy is contingent upon passing certain specified qualifying examinations. The communication and foreign language requirement for the Ph.D. degree is flexible, requiring none, one, or two foreign languages, depending on the individual's program; if less than two languages are allowed, appropriate substitutions involving interdisciplinary work that leads to the development of a strong area of application and/or computer science may be required. Emphasis is placed on helping the student expand his creative ability to solve real problems having statistical aspects.

While applications from all students (including those who already have done graduate work) are reviewed, completion of a standard calculus sequence is regarded as a prerequisite. Students with a 3.00 or better junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

STATISTICS (STAT)

401. Experimental Methods I (3)
402. Experimental Methods II (3)
403. Experimental Methods III (3)
409-410. (Math. 409-410) Introduction to Mathematical Statistics (3 each)
412. (Math. 412) Introduction to Mathematical Statistics (3)
418. (A.M. 418, Math. 418) Discrete Probability Theory (3)
427. (Math. 427) Discrete Stochastic Models (3)
451. Statistical Methods I (3)
452. Statistical Methods II (3)
453. Statistical Methods III (3)
461. Sampling Methods (3)
462. Applied Regression Analysis (3)
463. Applied Multivariate Analysis (3)
464. Applied Nonparametric Statistics (3)
490. Special Topics in Probability and Statistics (3-9)

501. LINEAR MODELS AND EXPERIMENTAL DESIGN I (3) Multivariate distribution theory, quadratic forms, linear transformations, matrix methods, estimation. Prerequisite: Stat. 410.

502. LINEAR MODELS AND EXPERIMENTAL DESIGN II (3) Full-rank theory, response surfaces, factorial experiments, likelihood ratio testing, cross classification models, interaction. Prerequisite: Stat. 501.

503. LINEAR MODELS AND EXPERIMENTAL DESIGN III (3) Study of special designs, hierarchal classification, variance components, testing and estimation theory, covariance analysis. Prerequisite: Stat. 502.

504. NONPARAMETRIC STATISTICS (3) Asymptotic and finite distribution theory, asymptotic efficiency, rank tests for location and dependence. Prerequisites: Stat. 410 and 3 additional credits in statistics.

505. MULTIVARIATE STATISTICAL ANALYSIS (3) Statistical procedures associated with the multivariate normal distribution. Prerequisites: Stat. 501; Math. 441 or 481.

506. SAMPLING THEORY (3) Theory and application of sampling from finite populations. Prerequisite: 6 credits in statistics.

507. SEQUENTIAL ANALYSIS (3) A thorough discussion of sequential procedures of estimation and testing of hypotheses. Prerequisite: Stat. 410.

508. CHARACTERIZATION OF STATISTICAL MODELS (3) Characteristics of different statistical distributions; characterizations of distributions through structural properties and statistical procedures. Prerequisite: Stat. 543.

509. DISCRETE STATISTICAL MODELS AND METHODS (3) Systematic study of probability models and statistical methods pertaining to statistical analysis of data consisting of single and multiple counts. Prerequisite: Stat. 554.

512-513. (A.M. 512-513) INTRODUCTION TO STOCHASTIC PROCESSES (3 each) Markov chains, random walk and recurrent events, queuing theory, time-dependent stochastic processes. Prerequisite: Stat. 418.

517-518. (Math. 517-518) PROBABILITY THEORY (3 each) Measure theoretic foundation of probability, distribution functions and laws, types of convergence, central limit problem, conditional probability, special topics. Prerequisites: Math. 452, 501.

524. ECOMETRICS (3) Stochastic models and statistical methods in ecological problems; population dynamics, spatial patterns in populations of one, two or more species. Prerequisite: Stat. 409 or 418.

528. QUEUING MODELS IN TRANSPORTATION (3) Arrival patterns, the service mechanism, queue discipline, delays, multiple queues, problems involving interrupted flow, multiflow routes.

542-543. (Math. 542-543) STATISTICAL DISTRIBUTION THEORY (3 each) Random variables and expectations; discrete, continuous, univariate, multivariate, exact, and asymptotic distribution theory. Prerequisites: Math. 421 and 441 or 481.

553. STATISTICAL ESTIMATION AND TESTING I (3) Point estimation of one parameter; sufficiency; completeness; maximum likelihood; interval estimation. Prerequisite: Stat. 543.

554. STATISTICAL ESTIMATION AND TESTING II (3) Neyman-Pearson theory and lemma; uniformly most powerful tests; unbiased tests; large sample procedures. Prerequisite: Stat. 553.

558-559. (Math. 558-559) THEORY OF STOCHASTIC PROCESSES (3 each) Stationary, independent, and orthogonal processes, discrete and continuous Markov processes, martingales and semi-martingales applications. Prerequisite: Stat. 518.

561. STATISTICAL INFERENCE I (3) Multiparameter estimation; linear estimation; maximum likelihood estimation; Bayesian estimation; large sample properties and procedures. Prerequisite: Stat. 554.

562. STATISTICAL INFERENCE II (3) Testing statistical composite hypotheses; invariance principles; Bayesian statistics; large sample properties and procedures. Prerequisite: Stat. 561.

572. STATISTICAL DECISION THEORY I (3) Structure of statistical games; optimal strategies, fixed sample-size games. Prerequisites: Math. 502, Stat. 561.

573. STATISTICAL DECISION THEORY II (3) Sufficient statistics; the invariance principle; estimation and testing. Prerequisite: Stat. 572.

577. (Math. 577) SPECIAL TOPICS IN PROBABILITY (3-12) Special topics in probability which are not offered regularly but which are of special interest to faculty and students.

591. (Math. 591) SEMINAR IN PROBABILITY THEORY (1-6) Lectures on current and recent research in various special topics in probability theory.

THEATRE ARTS (THEA)

DOUGLAS N. COOK, *Head of the Department*
103 Visual Arts Building

Degrees Conferred: M.A., M.F.A.

Graduate Faculty: Senior Members Manfull, Smith, Walters, and Yeaton.
Graduate Faculty: Associate Members Allison and Cook.

The M.A. program is planned to provide breadth of studies in theatre. A thesis in some area of specialization is required.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Requirements for admission to the M.A. program are:

1. A broad undergraduate preparation in theatre, including courses in basic acting, directing, theatre crafts, and theatre history (or their equivalents as indicated by evidence or practical experience in the theatre).

2. Eighteen credits in related subject areas, such as oral interpretation, dramatic literature, music, and art.

The M.F.A. program is planned to provide a professional emphasis. Specialization in the following areas is stressed: performance (acting or directing); production (scene design, costuming, lighting, or technical direction); or playwriting. A required final project in the area of specialization includes a monograph.

Requirements for admission to the M.F.A. program are:

1. Twenty-four credits in theatre arts, including one course each in acting, directing, and theatre crafts. Related courses in the student's area of specialization may be accepted.

2. All students are to submit evidence of ability in their areas of specialization under arrangements to be made with the department. Auditions, prompt books, portfolios, manuscripts, and other appropriate presentations are to be submitted by applicants to the various study programs.

3. Vitae and letters of recommendation (at least three) are to be submitted.

4. Personal interviews should be arranged by all students.

All students in the M.A. and M.F.A. programs who are deficient in the required undergraduate courses may be requested to take additional course work in the areas of deficiency without degree credit.

Under certain circumstances the Ph.D. degree is offered by the Department of English with specialization in drama and minor work in theatre arts.

All graduate majors are required to participate in University Theatre productions in positions of responsibility.

THEATRE ARTS (THEA)

401. HISTORY OF ANCIENT AND MEDIEVAL THEATRE (3)

402. History of Renaissance and Oriental Theatre (3)
403. History of Modern European and British Theatre (3)
405. History of American Theatre (3)
410. Creative Dramatics with Children (3)
411. Projects in Creative Dramatics (2)
416. Children's Theatre (3)
417. Staging Theatre for Children (3)
418. Marionettes and Puppetry (3)
424. Dance for the Theatre (3)
425. Dance for the Contemporary Musical Theatre (2-6)
427. Theatre Makeup (2)
429. Theatre Performance Practicum (1-6)
434. Directing (3)
435. Rehearsal Methods for the Director (3)
436. Central Staging (3)
445. Advanced Playwriting (3-6)
450. Advanced Scene Design (3-6)
460. Costume Design (3)
461. Costume Construction (3)
462. Drafting Historical Costumes for the Stage (3)
474. Stage Lighting (3)
479. Stage and Production Management (3)
485. Sound for Theatre Production (3)
489. Theatre Production Practicum (1-3)
490. Motion Picture Techniques (3-6)
491. Film Authors I (3)
492. Film Authors II (3)
493. Film Authors III (3)
495. Performance for the Camera (3)
496. Radio and Television Directing (3)

500. Theatre Research: Sources and Procedure (1) Materials and techniques as applied to theatre research; the form and content of theses and monographs.

503. Theatre Criticism and Theory (3)

505. Theatre History (3) Specific aspects of theatre from ancient times to the present.

522. Acting I (4) Interpretation of theatrical styles: the tradition of tragedy; voice and movement.

523. Acting II (4) Interpretation of theatrical styles: the tradition of comedy; voice and movement. Prerequisite: Thea. 522.

524. Acting III (4) Interpretation of theatrical styles: forms of modern realism; voice and movement. Prerequisite: Thea. 523.

525. Acting and Directing Theory (3) The actor and director as related to cultural environment from the Greek theatre through the post-Stanislavskian theorists.

528. Advanced Acting Projects (3-9) Advanced performance projects for the second- and third-year M.F.A. actor who has completed all other performance courses.

530. Play Interpretation for the Director (3) Theory and practice in the analysis and implementation of story, style, and form.

531. Special Forms in Directing (3) Applied theory and techniques for various genres and periods of drama. Prerequisite: Thea. 530.

533. Projects in Directing (1-6 per term)

535. Experimental Theatre (1-3) Operational research and experimental methods in the preparation, planning, execution, observation, and evaluation of production.

540. Playwriting (3-6) Focus on problems in writing the full-length script through seminar, play reading, and individual session.

543. PROJECTS IN PLAYWRITING (1-9) Preparation of the script for revision during and rewriting following production of the student's original play. Prerequisite: production approval.

553. DESIGN AND TECHNICAL PRODUCTION (1-6 per term) Special projects in design and technical execution of scenery, costumes, lighting, sound, and special effects.

560. COSTUME DESIGN (1-6) Design concepts, rendering, and execution of costumes for the stage.

574. LIGHTING FOR THEATRE PRODUCTION (3) Design techniques for production in arena, thrust, and proscenium theatre situations.

580. THEATRE TECHNOLOGY (3) Design consultation and specification of equipment, systems, and movable structures for new theatres; structures and projection devices for production.

582. THEATRE ADMINISTRATION (3) The theatre: organization and management.

583. PROJECTS IN THEATRE ADMINISTRATION, MANAGEMENT, AND OPERATIONS (1-6)

585. THEATRE PLANNING (3) Processes and problems in planning and designing theatres: performance, audience, and technical requirements.

591. SPECIAL PROBLEMS IN FILM AND TV (1-3 per term)

VETERINARY SCIENCE (V SC)

ALFRED L. BORTREE, *Head of the Department*
115D Animal Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Bortree, Dunne, Gentry, Glantz, and Rothenbacher.
Graduate Faculty: Associate Members Eberhart, Kradel, Scholz, Swope, and Zarkower.

Areas of specialization include veterinary pathology, veterinary physiology, and veterinary microbiology. There is opportunity for cooperative research with other departments in animal science, microbiology, and physiology. Unless excused by specific departmental action, all doctoral candidates must attain the master's degree as a step toward candidacy for the Ph.D. degree. A thesis is required of all candidates for the M.S. degree.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by proficiency in reading one foreign language. In the case of foreign students whose native language is other than English, this requirement may be waived with the approval of the doctoral committee.

Prerequisites for admission are a veterinary degree or a bachelor's degree in a related biological field. Adequate preparation in the basic sciences compatible with the candidate's objectives is required. Students may be admitted with limited deficiencies and are required to remove undergraduate deficiencies without degree credit.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. Academic records of candidates with the Doctor of Veterinary Medicine degree or M.S. degree will be reviewed and acted on by the graduate faculty of the department.

VETERINARY SCIENCE (V SC)

401. ECOLOGY OF ANIMAL DISEASE (3) *Mr. Kradel*
405. LABORATORY ANIMAL SCIENCE (3) *Mr. Ferguson*
418. METHODS OF ANIMAL CELL CULTURE (3) *Mr. Patton*
420. GENERAL ANIMAL PATHOLOGY (3) *Mr. Dunne*

525. Mechanisms of Hypersensitivity and Immunopathology (3) Concepts of hypersensitivity and special consideration of immunopathological conditions. Prerequisites: Biol. 437, Micrb. 410, and 3 credits of pathology. *Mr. Zarkower*

528. Diagnostic Pathology (3-9) Gross examination of animals and birds, their tissues and body fluids for pathologic changes. Prerequisites: 6 credits in pathology, microbiology, or infectious diseases.

535. Acquired and Congenital Disorders of Metabolism (3) Abnormalities and alterations in metabolism due to dysfunctions of animal organs. Prerequisites: 6 credits in general biochemistry and 3 credits in animal physiology. *Mr. Scholz*

581. Seminar in Veterinary Science (1-4) Presentation and critical discussion of results of personal research or topics of current interest.

582. Special Problems (1-9) Investigation of special disease problems, including laboratory and field studies.

VOCATIONAL INDUSTRIAL EDUCATION (VI ED)

Angelo C. Gillie, *In Charge of Graduate Programs in Vocational Industrial Education*
248 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Brandon and Gillie.
Graduate Faculty: Associate Members Brantner, Kapes, Long, and Williams.

Emphasis may be placed upon preparation for teaching, supervision, administration, research, or teacher education. The primary focus of the program is preparation for entry into responsible positions within the broadly conceived field of vocational education.

The communication and foreign language requirement for the Ph.D. degree may be met by the successful completion of selected courses in statistics and computer programming.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

INDUSTRIAL EDUCATION (I ED)

402v. Supervision of Vocational Education (3)
403v. Supervised Field Work (6)
408v. Occupations (3)
409v. Tests and Measurements (3)
412v. Special Problems in Vocational Education (6)
415v. Problems in Coordinating Vocational Education (3)
420v. Occupational Hygiene (3)
427v. Advanced Course of Study Building (3)
446v. Improvement of Instruction in Vocational Education (4)
450v. Shop Layout and Management (3)

501v. Seminar in Vocational Education (6) Conferences, investigations, and discussion for advanced students and mature persons who have had experience as teachers, supervisors, or administrators.

506v. Administration of Vocational Education (3) The job of the local director of industrial education in organizing and developing city and other local programs of industrial education. Prerequisite: 6 credits in industrial education, valid director's certificate, or equivalent training and experience.

510v. VOCATIONAL EDUCATION FOR ADMINISTRATORS (3) Designed for school administrators and supervisors who desire an understanding of practical arts and vocational education. Prerequisite: I.Ed. 1v or trade or teaching experience.

550v. RESEARCH IN VOCATIONAL EDUCATION (3) Research techniques in vocational industrial education.

556v. FEDERAL LEGISLATION (2-3) Recent federal legislative activities and executive orders that bear directly and indirectly upon industrial education.

557v. PRESENT-DAY LOCAL, PERSONNEL, AND CURRICULUM PROBLEMS (2-3) Various plans, techniques, and practices.

558v. STATE AND LOCAL SUPERVISION AND ADMINISTRATION (2-3) The more important recent problems in organization, supervision, and administration.

559v. VOCATIONAL TECHNICAL EDUCATION (2-3) Problems of organization and administration of programs of technical education at the secondary and post-secondary levels. Prerequisite: 6 credits in industrial education, valid director's certificate, or equivalent training and experience.

560v. PHILOSOPHY OF INDUSTRIAL EDUCATION (3) Principles and beliefs of progressive industrial education; literature for evaluating instructional practices. Prerequisite: 12 credits in industrial education or teaching experience.

WILDLIFE MANAGEMENT (W L M)

WILBER W. WARD, *Director of the School of Forest Resources*
101 Ferguson Building

Degree Conferred: M.S.

Programs are designed to prepare students for positions in wildlife research and management. Specialized training may be directed toward animal ecology, nutrition, physiology, behavior, or pathology.

Applicants should present a minimum of 12 credits in mathematics including at least 6 credits in statistics and/or computer science, 15 credits in chemistry and physics, and 33 credits in biological sciences including courses in forestry or wildlife. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

WILDLIFE (WILDL)

408. MAMMALOGY (3)
446. WILDLIFE ECOLOGY (3)
447. WILDLIFE MANAGEMENT (3)
492. FIELD RESEARCH TECHNIQUES (3)
493. LABORATORY RESEARCH TECHNIQUES (2)
497. PROBLEMS IN WILDLIFE (1-3)

ZOOLOGY (ZOOL)

JOSEPH G. O'MARA, *Head of the Department of Biology*
208 Life Sciences I Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Anthony, Bellis, Butler, Cooper, Dalton, Dunson, Gaffney, Hale, Hibbard, Hymer, Wickersham, and Williams.
Graduate Faculty: Associate Members Abplanalp, Hollis, Mitchell, and Neff.

This program offers emphasis in animal behavior, cell biology, developmental biology, ecology, endocrinology, fishery biology, genetics, histology, ichthyology, invertebrate zoology, morphology, physiology, or population dynamics.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

The bachelor's program must show emphasis on zoological subjects and include adequate preparation in mathematics and physical sciences. Each applicant must provide Graduate Record Examination scores, letters from two persons most familiar with his academic qualifications, and a personal statement of his primary interests and objectives.

Admission is restricted to students who have the baccalaureate degree in a biological science and who present a cumulative undergraduate average of at least 3.00. Each applicant must provide scores from the Graduate Record Examination, letters from two persons who are familiar with his academic competence, and a personal statement of his interests and objectives.

See also Genetics and Physiology.

NOTE: *For courses in Zoology and related subjects see Biology.*

OTHER ELECTIVE GRADUATE COURSES

The following courses are in fields in which neither major nor minor work is offered at this institution. The courses, however, carry graduate credit and, with the approval of the major department head or program chairman, may be applied toward the requirements for a degree either as elective courses or as a part of a general studies program. The usual restrictions upon the use of 400 series courses in degree programs apply to these courses.

AGRICULTURE, GENERAL (AG)

400. Introductory Biometry (3)

AMERICAN STUDIES (AM ST)

402. Seminar in American Studies (3-9)

501. Theory and Methods of American Studies (3) Theory and methods for the analysis of American culture: history of ideas, analysis of myth and symbol, comparative arts, etc.

502. Problems in American Studies (3-6) A variable-content course, addressed each term to a specific problem, topic, or period in American culture.

ANIMAL SCIENCE (AN SC)

422. Quantitative Inheritance and Animal Breeding (3)
455. Animal Genetics (2)

APPLIED MATHEMATICS (A M)

405. (Math. 405) Fourier Series and Partial Differential Equations (3)
417. (Math. 417) Tensor Analysis (3)
418. (Math. 418, Stat. 418) Discrete Probability Theory (3)
419. (Phys. 419) Theoretical Mechanics (3)
431. (Math. 431) Ordinary Differential Equations (3)
441. (Math. 441) Matrix Algebra (3)
451. Functions of Several Variables (3)
452. (Math. 452) Functions of a Complex Variable (3)
461. (Phys. 461) Theoretical Mechanics (3)
490. Special Topics (1-12)

510-511. Linear Methods (3 each) Matrices, quadratic forms, ordinary and partial differential equations, integral equations, transforms, Fourier series. Prerequisite or concurrent: A.M. 452.

512-513. (Stat. 512-513) Introduction to Stochastic Processes (3) Markov chains, random walk and recurrent events, queuing theory, time-dependent stochastic processes.

520. Asymptotic Techniques in Differential Equations (3) Asymptotic series; applications to ordinary and singular perturbation problems. Prerequisite: A.M. 511.

550. (Phys. 550) Applied Group Theory (3) Representations of discrete and continuous groups, applications to theoretical physics and differential equations, varying emphasis on the specific applications. Prerequisite: A.M. 510.

555. Introduction to Group Representations (3) An introduction to matrices, groups, group representations, characters, and orthogonal functions, with orientation to chemistry and physics.

573. Special Topics (2-12) Various topics according to instructor and students. Prerequisite: second-year graduate standing.

THE ARTS (ARTS)

400. Contemporary Forms in the Arts (3)

BEHAVIORAL SCIENCE (BEHSC)

501. Behavioral Science (4) Integration of bio-psycho-social substrates of behavior, variability in behavior during development, and behavioral correlates with disease and health.

502. Behavioral Science (3) Continued integration of bio-psycho-social substrates with emphasis on adaptation, during development, and behavioral correlates with disease and health.

503. Behavioral Science (3) Continued integration of behavioral substrates with emphasis on personality, emotions, nervous system, stress, behavioral correlates of disease, communication, and society. Prerequisite: Beh.Sc. 502.

511. Medical Statistics and Research Design (2) Use of theoretical and applied statistics in medical research design and in the interpretation of data.

521. Primate Behavior (3) Monkey-to-man survey of intelligence, learning, social behavior, emotions, growth, and physiology; techniques of primate research.

531. Behavioral and Physiological Correlates of Stress (3) Effects of stress on all physiological processes and role of learning, cognition, personality, and culture in adapting to stress.

535. Nervous Systems and Behavior (3) Synthesis on behavioral science, neurobiology, and physiology with emphasis on integrative functions of peripheral, central, and autonomic nervous systems.

537. Mechanisms of Memory (2) Discussion of physiological mechanisms involved in information storage and retrieval. Experimental design in memory research is emphasized.

540. Seminar (1-6) Critical discussion of current literature and research within the behavioral sciences, emphasizing research design, methods, interpretation, and synthesis.

551. Health, Illness, and Culture (3) A medical sociology seminar devoted to the sociocultural aspects of health and sickness.

555. Behavior Change (3) Review of behavioral science research and theory relevant for behavior change procedures used in medicine.

570. Special Topics (1-6) Original and current literature and research methods in special areas in the behavioral sciences.

590. Research Problems (3-12) Independent work to develop and test creative and original hypotheses.

BIOLOGICAL HEALTH (B H)

403. Child Health Needs and Services (3)

BUSINESS EDUCATION (BUSED)

456. Principles and Problems in Business Education (1-3)
459. Improvement of Instruction in Business Skill Subjects (1-3)
460. Curriculums in Business Education (3)
461. Improvement of Instruction in Basic Business Subjects (3)
462. Teaching of Shorthand and Typewriting (3)
463. Teaching of Bookkeeping (3)

575. Administration and Supervision in Business Education (3) Work of administrators, supervisors, and others responsible for improvement of instruction in business education; use of vocational testing; job analysis. Prerequisite: 6 credits in secondary education.

576. Introduction to Research in Business Education (3) Methods of research in business education; opportunity to compile annotated bibliographies on current problems; analysis and evaluation of significant research.

577. Evaluation of Research and Empirical Literature in Business Education (3) Application of evaluation methods to current literature in business education; special attention to research studies. Prerequisite: Bus.Ed. 576.

578. Seminar in Business Education (1-6) Intended for graduate students preparing theses or final documents, or for those working on special studies in business education. Prerequisite: Bus.Ed. 577.

CHINESE (CHNS)

489. Readings in Chinese (1-6)

COMMUNITY DEVELOPMENT (COM D)

401. Socioeconomic Change and the Process of Dislocation (3)
402. Politics, Policy, and Community Action (3)
403. Ideal Communities (3)
404. Interpersonal and Group Processes in Community Change (3)
405. Community Mental Health: An Ecological Approach to Human Services (3)
406. Planning and Evaluating Human Service Programs (3)
407. Community Conflict (4)
417. Identifying Community Power Structures (3)
418. Community Organizing (5)
419. Comparative Community Development (3)

CONSUMER STUDIES (C S)

416. (I.F.S. 416) Consumer Role of Family (3)
420. Consumer Industries (4)
430. Societal Aspects of Consumer Problems (2)

CULTURAL FOUNDATIONS OF EDUCATION (CF ED)

415. Anthropology of Education (3)
416. (Soc. 416) Sociology of Education (3)
417. Philosophic Basis of Education (3)
418. History of Education in the United States (2-3)
419. History of Education in Ancient and Medieval Times (3)
420. History of Modern European Education (3)
422. Introduction to Comparative Education (3)
466. Race, Poverty and the Schools (3)

515. Experimentalist Philosophies of Education (2-3) John Dewey's educational philosophy and later formulations by Bode, Kilpatrick, Childs, Brameld, and others. Prerequisite: C.F.Ed. 417 or 6 credits in philosophy.

516. Topical Seminar on School and Society (2-6) An intensive and comprehensive analysis of one selected aspect of the relationship of educational institutions to their societal setting. Prerequisite: C.F.Ed. 416.

517. Existential Philosophy of Education (3) The nature, aim, organization, policy, and process of education examined from the viewpoint of existential philosophy and existential phenomenology. Prerequisite: C.F.Ed. 417 or 6 credits in philosophy at the 400 level or above.

519. Contemporary Philosophies of Education (2-3) Implications for education of various types of Realism, Idealism, Existentialism, and Analytic philosophy. Prerequisite: C.F.Ed. 417 or 6 credits in philosophy.

521. Education in the Latin-American Countries (2-3) Recent educational progress in Central and South America, with special reference to Mexico, Cuba, Puerto Rico, Brazil, Chile, and Argentina. Prerequisite: C.F.Ed. 422 or 6 credits in Latin-American studies.

522. Comparative European Education (2-3) Educational policies and practices in school systems in western and central European nations. Prerequisite: C.F.Ed. 422.

524. Education in Communist Countries (2-3) Educational policies and practices in Soviet Russia and other Communist countries. Prerequisite: C.F.Ed. 422 or 6 credits in Russian or Asian studies.

526. Education in Developing Countries (2-3) Educational problems and trends in selected countries, with particular reference to Africa, the Middle East, and Southeast Asia. Prerequisite: C.F.Ed. 422 or 6 credits in Asian, African, or Latin-American studies.

528. Education in Canada (2-3) Development and organization of education in the Canadian provinces; emphasis on dual systems of Ontario and Quebec. Prerequisite: C.F.Ed. 422.

532. Social Change, Cultural Dynamics, and Education (2-3) The social role of the school in a rapidly changing society. Prerequisite: C.F.Ed. 416.

534. Readings in Philosophy of Education (1-6) Selected philosophic writings — classic, modern, or contemporary — on education. Prerequisite: C.F.Ed. 417 or 6 credits in philosophy.

536. Educational Leaders and Classics (2-3) Selected leaders and their writings, with emphasis on historical-social context, including Quintilian, Erasmus, Comenius, Fénelon, Pestalozzi, and Mann.

592. Seminar in Cultural Foundations of Education (1-9) Conferences and discussions designed to meet the need for special study of particular areas in cultural foundations of education. Prerequisites: 12 credits of graduate work in cultural foundations of education.

EARTH AND MINERAL SCIENCES (EM SC)

420. Energy and Modern Society (3)
421. Materials and Modern Society (3)
496. Special Projects (1-6)

EDUCATION (ED)

470. Special Topics in Education for Collaborative Study (1-9)

ENGINEERING (ENGR)

410. (S.T.S. 410) Technology — Its Character, Role and Function (3)
450. Patent Fundamentals (3)

500. Special Topics in Engineering (1-3)

ENGINEERING GRAPHICS (E G)

421. Engineering Graphics for Teachers (3)

ENGINEERING SCIENCE (E SC)

405. Engineering Applications of Field Theory (3)

ENVIRONMENTAL RESOURCE MANAGEMENT (E R M)

400. Senior Seminar (1)
401. Special Studies (1-4)
410. Pollution of Environmental Systems (3)
411. Legal Aspects of Resource Management (2)
412. Resource Systems Analysis (3)
413. Case Studies in Ecosystem Management (3)

FAMILY AND COMMUNITY MEDICINE (FCMED)

510. Normal Sexual Development (1) The basis, development, and pattern of normal sexual development, with an emphasis on the range of "normal."

515. Economics of Health Care (1) Health costs and various means of meeting them.

527. Community Health Agencies (2) Students individually study community health agencies in depth, sharing experiences in seminars with other participants, agency personnel, and faculty.

GEOLOGICAL SCIENCES (G SC)

412. Geology of the Solar System (3)
416. Stable and Radioactive Isotopes in Geosciences: Introduction (3)
471. Field Studies in North America (3)

547. Evolution in Ecosystems (3) Evolutionary attributes of ecosystems; manifestation of evolutionary mechanisms in ecological systems; evolution of interspecies integrations; evolution of selected ecosystems.

Note: *More specialized courses in this field are listed under Geochemistry, Geology, Geophysics, or Mineralogy and Petrology.*

HEALTH PLANNING AND ADMINISTRATION (H P A)

410. Principles of Public Health Administration (3)
420. Environmental Health (3-6)
430. Principles of Health Planning (3)
431. Health Planning Methods (3)
432. Health Systems Management (3)
433. Health Systems Theory (3)

HUMAN DEVELOPMENT (H DEV)

400. Special Problems in Human Development (1-6)
401. Professional Issues in Human Development (1-3)
499. Senior Thesis (1-10)

516. Methods of Research in Human Development (1-6) Review of problems and techniques of research in human development.

HUMANITIES (HUMAN)

421. The Politics of Professionalism (3)
431. Science and American Democracy (2)
471. Humanistic Studies (1-4)
490. (C.&S. 490) Humanities for Teachers (3)

504. Human Values in Medical Care (2) Analysis of questions, concepts, and ramifications of moral and religious values of health and illness; principles of professional responsibility.

521. Philosophical Ethics (2) A critical delineation and examination of the conceptual framework of ethics.

526. Philosophy of Science (2) An introduction to the basic concepts of the philosophy of science.

541. Science and American Democracy (2) The development of the sciences and institutions of scientific endeavor from colonial times to the modern era.

570. Special Topics (1-6) Specialized study of selected topics in the humanities.

INTERNATIONAL UNDERSTANDING (INT U)

400. World Affairs and International Understanding (3-6)

ITALIAN (IT)

415. Dante (3)
420. Petrarca and Boccaccio (3)
425. The Literature of the Italian Renaissance (3)
450. Nineteenth-Century Italian Literature (3)
460. Twentieth-Century Italian Literature (3)
497. Problems in Italian Literature (3-10)

588. Seminar in Italian Literature (3-12) Common and individual research in special problems.

LABOR STUDIES (L S)

400. Comparative Industrial Relations Systems (3)
411. Trade Union Administration (3)
413. (Econ. 413) Comparative Labor Movements (3)
414. (Econ. 414) Theories of the Labor Movement (3)
415. Labor Movements in Developing Areas (3)
433. (Pl.Sc. 433) The Law of Labor-Management Relations (3)
435. Labor Relations in the Public Sector (3)
454. (Soc. 454) Industry and the Community (3)
455. (Soc. 455) Occupations and Professions (3)
456. (Hist. 456) History of American Labor (3)
457. (Soc. 457) Field Work in Industrial Society (1-6)
489. Problems in Labor Studies (1-9)

LANDSCAPE ARCHITECTURE (LARCH)

420. Landscape Ecology (3)
425-426. Landscape Construction Problems (3 each)
427. Landscape Construction Problems (2)
434. Urban Park and Recreation Areas (3)
454-455. Landscape Design (3 each)
460-461-462. Advanced Landscape Design (4-8 each)
471. Park Systems (2)
472. Planning and Public Policy (3)
473. Recreation Resource Planning (3)
474. Site Engineering Fundamentals (1)
475. Park Systems Practicum (1)

518. Advanced Problems in Landscape Design (2-12) Selected problems for original investigation in the design, construction, and maintenance of landscape architectural projects.

521. Technical Landscape Architectural Practices (2-12) Specific technical and professional problems in landscape architectural planning and practice. Prerequisites: L.Arch. 462, 471.

LAW ENFORCEMENT AND CORRECTIONS (L E C)

401. Probation, Parole, and Pardons (3)
410. Correctional Counseling Processes (3)
430. Correctional Institutions and Services (3)
470. Law of Crimes and Corrections (3)
480. Research Literature on Crime and Corrections (3)

LIBERAL ARTS (L A)

450. Independent Study (1-9)
460. Undergraduate Internship (1-4)
461. Academic Adviser Training (1)
480. (S.T.S. 480) Technological Change and Human Values (3)
489. Undergraduate Seminar: Selected Topics (3-9)

LITHUANIAN (LITH)

500. Structure of Lithuanian (3) Analysis of the phonology, morphology, and syntax of Lithuanian; comparative linguistic study of Balto-Slavic and Indo-European. Prerequisite: one graduate course in linguistics.

MATERIALS SCIENCE (MATSC)

401. Materials Science for Teachers I (3)
402. Materials Science for Teachers II (3)
404. Process Measurement and Control (1)
406. Introduction to Biomedical Materials (3)
411. (Min. 411) Instrumental Techniques Applied to Materials and Mineral Science Problems (1-5)
Unit A. X-Ray Diffraction
Unit B. Electron Microscopy
Unit C. Spectroscopy
Unit D. Electron Probe Analysis
Unit E. Scanning Electron Microscopy
412. Quantitative Microstructural and Particulate Characterization (1)
416. Materials Preparation (2)
420. Mathematical Modelling for Materials Scientists (3)
421. (Min. 421) X-Ray Diffraction (3)
490. Special Topics in Materials Science (1-9)

500. Materials Research for Teachers (3) Independent research on a problem from materials science. Topic chosen by consultation with the supervising faculty. Written report required. Prerequisite: Mat.Sc. 402.

512. (Gchem. 512) Principles of Crystal Chemistry (2-4) Relation of structure to ionic size and nature; influence of pressure and temperature on structure; chemical-structural defects, crystalline solutions, phase-transitions.

514. Characterization of Materials (3) Classical and new (microprobe, scanning microscope, magnetic resonance, and Mossbauer) techniques for the characterization of composition, structure, defects, and surfaces.

524. (Gchem. 524) Vibrational Spectra of Materials and Minerals (2) Infrared and Raman spectroscopy of solid materials with applications to crystal chemistry, materials characterization and glass research. Prerequisites: Phys. 412, 471.

531. (Min. 531) Transmission Electron Microscopy (2) Discussion of electron image contrast theory as a tool for study of atomic substructures in the materials and mineral sciences. Prerequisite: Mat.Sc. (Min.) 411B.

532. (Min. 532) Structure Analysis (2) Crystal structure determination methods: space groups, structure factors, heavy atoms and isomorphous replacement, Fourier synthesis, Patterson maps, inequalities, refinement techniques. Prerequisite: Mat.Sc. (Min.) 421.

533. (Min. 533) Single Crystal Methods (2) Experimental techniques in crystal structure determination: crystal selection, space group determination, measurement of intensities, analysis of data. Prerequisite: Mat.Sc. (Min.) 421.

534. (Min. 534) DIFFRACTION BY CRYSTALS (2) Interaction of radiation with matter: coherent and incoherent scattering, extinction, fluorescence, polarization. Prerequisite: Mat.Sc. (Min.) 421.

535. (Min. 535) GEOMETRICAL CRYSTALLOGRAPHY (3) Derivation of lattices, types, point groups and space groups with applications.

538. (Min. 538) ELECTRON BEAM ANALYSIS OF SOLIDS VIA X-RAY AND ELECTRON EMISSION (3) Theory of phenomena occurring in electron-bombarded solids and their applications to analysis of solids.

540. CRYSTAL ANISOTROPY (2) Symmetry aspects of crystals and physical properties. Matrix and tensor methods. Prerequisite: Phys. 412.

542. MAGNETIC METHODS IN MATERIALS SCIENCE (3) Static magnetic (susceptibility type) and spectroscopic methods (nuclear and electron magnetic resonance, Mossbauer spectroscopy) for materials characterization and structural analysis. Prerequisite: Phys. 413.

550. EVAPORATION AND CONDENSATION OF SOLIDS (2) Thermodynamics of evaporation and condensation of solids; condensation processes including thin films and epitaxial growth and their applications.

552. THEORY AND PRACTICE OF CRYSTAL GROWTH (3) Theoretical approaches to crystal growth and of the various techniques used in growing crystals.

554. ELECTRONIC SPECTRA OF MATERIALS (2) Crystallographic and thermodynamic applications of crystal field theory. Electronic spectra of crystals and glasses. Luminescent spectra and phosphor characterization. Prerequisite: Phys. 471.

564. STRUCTURE AND PROPERTIES OF CARBONS AND GRAPHITE (3) Relation of the ideal and defect structure of polycrystalline carbons and graphite to their mechanical, electronic, thermal, and optical properties. Prerequisite: Phys. 412.

570. CATALYTIC MATERIALS (3) Preparation and characterization of solid catalytic materials. Relationships between their surface, defect, and electronic properties and catalytic activity. Prerequisite: Chem. 452.

MINERAL ENGINEERING (MIN E)

424. (Metal. 424) COAL PREPARATION (3)

PHYSIOLOGY (PHSIO)

520. MEDICAL PHYSIOLOGY (2) Cellular physiology including membrane permeability; bioelectric potentials, muscle contractions, secretion; cardiovascular physiology including hemodynamics, cardiac function and output, peripheral circulations.

521. MEDICAL PHYSIOLOGY (4) Organ and metabolic physiology, including renal, endocrine, neuromuscular, gastrointestinal, and respiratory.

525. GENERAL PHYSIOLOGY (2) Cellular processes of accumulation membrane transport, bioelectric potentials, contraction, and secretion in erythrocytes, nerves, sensory receptors, muscles, glands, excretory organs.

530. METABOLIC AND ENDOCRINE PHYSIOLOGY (3) Regulations of carbohydrates, fatty acid and protein metabolism; regulation of hormone secretion; effects of hormones on water and cell metabolism.

532. REPRODUCTIVE PHYSIOLOGY (3) Physiology of male and female reproductive systems, including synthesis, regulation of secretion, and mechanism of action of the steroids and polypeptide hormones involved. Prerequisites: Phsio. 520, 521.

534. HEART AND SKELETAL MUSCLE (2) Discussion of structure, chemistry, and physiology of heart and skeletal muscle. Prerequisites: Phsio. 520, 521.

536. GASTROINTESTINAL PHYSIOLOGY (2) Mechanisms of absorption and secretion by stomach, intestine, pancreas, and gallbladder. Neural and hormonal regulation, bioelectric potentials, pathophysiology. Prerequisite: Phsio. 521.

550. SEMINAR (1 per term) Critical appraisal by staff and students of current research developments and of data collected in current investigations.

570. SPECIAL TOPICS (1-6) Training in the use of research techniques; examination in depth of a specialized topic on the level of current research.

590. RESEARCH PROBLEMS (1-12) Individualized research conducted by students in departmental laboratories.

PLANT SCIENCE (PLTSC)

400. PRINCIPLES OF PLANT SCIENCE RESEARCH (2)
401. INDEPENDENT STUDY IN PLANT SCIENCES (1-6)

POLISH (POL)

501. READINGS IN POLISH LITERATURE (3-6) Individual reading and research in nineteenth and twentieth century Polish literature and literary criticism.

POLYMER SCIENCE (PLMSC)

406. INTRODUCTION TO THE MATERIALS SCIENCE OF POLYMERS (3)
407. TECHNOLOGY AND APPLICATIONS OF POLYMERIC MATERIALS (3)
408. POLYMERIC MATERIALS LABORATORY (1)
409. INTRODUCTION TO PROPERTIES OF POLYMERIC MATERIALS (3)
410. POLYMER-BASED COMPOSITE MATERIALS (3)

560. PROPERTIES OF POLYMERIC MATERIALS (3) Macroscopic and microscopic behavior of polymeric materials. Interpretation of properties in terms of structure. Prerequisite: Plm.Sc. 406.

562. POLYMERIC MATERIALS CHARACTERIZATION LABORATORY (2) Characterization of polymeric materials by chemical and physical methods. Prerequisite: Plm.Sc. 406.

565. POLYMERIC BIOMEDICAL MATERIALS (3) Synthetic high polymers: their properties and uses in biomedical applications.

POPULATION ISSUES

Qualified students may select Population Issues as an optional area of specialization when majoring either in economics, geography, or sociology. Additional information is given under the description of those majors in the preceding section.

PORTUGUESE (PORT)

588. SEMINAR IN PORTUGUESE AND BRAZILIAN LITERATURE (3-12) Common and individual research in special problems.

SAFETY EDUCATION (SAFED)

449. SAFETY EDUCATION (3)
450. VISUAL AND OTHER AIDS IN SAFETY EDUCATION (3)
451. TEACHING TRAFFIC SAFETY AND AUTOMOBILE OPERATION (3)
452. ORGANIZATION AND SUPERVISION IN SAFETY EDUCATION (3)

SCIENCE, TECHNOLOGY, AND SOCIETY (S T S)

410. (Engr. 410) TECHNOLOGY: ITS CHARACTER, ROLE, AND FUNCTION (3)
430. FOOD AND MAN: TECHNOLOGY AND FEEDING THE WORLD POPULATION (3)
435. (Phil. 435) THE INTERRELATION OF SCIENCE, PHILOSOPHY, AND RELIGION (3)
450. TECHNOLOGICAL CHANGE: ITS PRODUCTION, DIFFUSION, AND IMPACT (3)
460. SCIENCE AND PUBLIC POLICY (3)
470. TECHNOLOGY ASSESSMENT AND INDICATORS OF THE QUALITY OF LIFE (3)
471. RADIATION, REACTORS, AND SOCIETY (3)

480. (L.A. 480) TECHNOLOGICAL CHANGE AND HUMAN VALUES (3)

NOTE: This program is designed to examine critically the impact of scientific investigation and technological development on society and the influence of human needs on scientific investigation and technological development.

ADDITIONAL GRADUATE COURSES

The following courses are offered in the Division of Academic Curriculum and Instruction in the College of Education and are applicable to graduate degrees in elementary, industrial arts, and secondary education. The usual restrictions upon the use of 400-series courses in degree programs apply to these courses.

CURRICULUM AND SUPERVISION (C & S)

400. INTRODUCTION TO RESEARCH LITERATURE (3)
401. MEASUREMENT AND EVALUATION OF INSTRUCTION, K-12 (3)
402. PROFESSIONAL TERM IN ELEMENTARY EDUCATION (12)
403. PRACTICUM IN STUDENT TEACHING (10)
404. PROFESSIONAL ORIENTATION OF THE ELEMENTARY TEACHER (3)
470. WORKSHOP IN SELECTED STUDIES IN CURRICULUM (1-6)
471. WORKSHOP IN SELECTED STUDIES IN SUPERVISION (1-6)
472. ADVANCED THEORY OF KINDERGARTEN (3)
473. SECONDARY EDUCATION IN AMERICA (3)
490. (Human. 490) HUMANITIES FOR TEACHERS (3)

570. PROBLEMS SEMINAR FOR EXPERIENCED EDUCATORS (3) Historical, psychological, social, and economic factors influencing educational programs. Prerequisite: 12 credits in education and psychology.

571. SEMINAR IN CONTEMPORARY ISSUES IN ELEMENTARY EDUCATION (1-3) Conferences and discussions designed to meet the needs of experienced teachers and principals in the field of elementary education. Prerequisites: 6 credits in elementary education and teaching experience.

572. ISSUES AND TRENDS IN EARLY CHILDHOOD EDUCATION (3) Research, experimental programs and emerging trends in early childhood education; relationships between educational experiences and later intellectual and emotional development. Prerequisites: C.&S. 472, Ed.Psy. 400.

573. ORGANIZATION OF THE ELEMENTARY SCHOOL CURRICULUM (3) Principles underlying curriculum construction. Primarily for elementary education majors. Prerequisite: C.&S. 402 or teaching experience.

575. ORGANIZATION OF THE SECONDARY SCHOOL CURRICULUM (3) Functions of laymen, pupils, teachers, supervisors, and administrators in secondary school curriculum construction. Prerequisites: 12 credits in education and psychology, and teaching experience.

576. CURRICULUM THEORY K-12 (3) The analysis and use of the foundations which underlie models of curriculum design. Prerequisite: C.&S. 573 or 575.

577. SEMINAR IN CURRICULUM RESEARCH (3) Seminar designed to meet the need for special study of particular research projects in elementary and secondary education. Prerequisite: 12 credits of graduate work in education.

579. WORKSHOP IN CURRICULUM AND SUPERVISION (1-6) For experienced teachers and supervisors involved in changing educational programs.

580. SUPERVISION OF STUDENT TEACHERS (3) A course in supervision for master teachers, department heads, and college teachers with supervisory responsibilities in teacher education. Prerequisites: teaching experience and 18 credits in education including at least 5 in methods.

581. PRINCIPLES OF INSTRUCTIONAL SUPERVISION (3) Social and institutional settings for instructional supervision; functions, activities, and practices of supervision; supervisory case studies.

582. SYSTEMATIC OBSERVATION OF INSTRUCTION (3) Construction and use of valid and reliable systematic observation systems used as a basis for classroom observation of instruction. Prerequisite: student teaching or teaching experience.

583. INTERNSHIP IN CURRICULUM AND SUPERVISION (3-6) Internship in schools or educational facilities where student is not employed, under supervision of graduate faculty in student's major area.

588. PROBLEMS, PROJECTS, AND AREA STUDIES IN CURRICULUM AND INSTRUCTION (1-6) Independent work in the study of topics in curriculum and instruction; development of new curricula, materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of program chairman.

INDUSTRIAL ARTS EDUCATION (IA ED)

460. PLANNING AND MANAGEMENT OF INSTRUCTIONAL RESOURCES (3)
461. TECHNOLOGY IN THE ELEMENTARY SCHOOL (3)
462. INDEPENDENT STUDY IN INDUSTRIAL STUDIES (2)
463. SELECTED TOPICS IN INDUSTRIAL STUDIES (1-6)
464. CURRICULUM AND INSTRUCTION: INDUSTRIAL STUDIES (3)
465. PREPROFESSIONAL EXPERIENCE IN INDUSTRIAL STUDIES (1-3)

561. HISTORY AND PHILOSOPHY OF INDUSTRIAL ARTS (2-3) Historical developments and concurrent educational philosophies of industrial arts in American education.

562. CURRICULUM DEVELOPMENT IN INDUSTRIAL ARTS EDUCATION (2-3) Analysis of curriculum innovations in industrial arts and cognate fields; strategies for implementing curricular change; construct and assess curriculum materials. Prerequisite or concurrent: I.A.Ed. 561. Prerequisite: teaching experience.

563. SUPERVISION AND ADMINISTRATION OF INDUSTRIAL ARTS EDUCATION (2-3) How to organize, supervise, and administer functioning programs of industrial arts; duties of a supervisor and director of industrial arts. Prerequisite or concurrent: I.A.Ed. 562. Prerequisite: teaching experience.

564. EVALUATION IN INDUSTRIAL ARTS (2-3) Construction of informal manipulative and written tests; use of standardized mechanical aptitude tests; construction and use of performance rating scales. Prerequisite: C.&S. 400 or 401.

568. RESEARCH IN INDUSTRIAL ARTS (2-3) Research techniques in industrial arts education. Prerequisite or concurrent: C.&S. 400.

569. SEMINAR IN INDUSTRIAL ARTS (1-9) Directed intensive study, investigation or research in selected phases of the program; reports and constructive criticism. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

INSTRUCTIONAL MEDIA (INSTM)

411. ORIENTATION TO INSTRUCTIONAL MEDIA (2)
412. PRODUCTION AND UTILIZATION OF GRAPHIC STIMULUS MATERIALS (3)
413. PRODUCTION OF EDUCATIONAL MOTION PICTURES (3)
414. TELEVISION IN EDUCATION (3)

511. ORGANIZATION AND ADMINISTRATION OF MEDIA IN SCHOOLS (3) Problems of providing instructional media in schools; the role of the media consultant in curriculum construction. Prerequisite: Inst.M. 411.

LANGUAGE EDUCATION (L ED)

440. The Elementary School Reading Program (3)
441. Teaching Children's Literature (3)
442. The Elementary School Language Arts Program (3)
443. Teaching English in the Secondary Schools (4)
444. Seminar in Foreign Language Instruction (3)
445. Teaching English to Dialect and Nonnative Speakers (3)
446. (Rl.St. 446) Western Religious Literature for Secondary School Teachers (3)
447. (Rl.St. 447) Eastern Religious Literature for Secondary School Teachers (3)
448. Language Teaching in School Programs (3)
449. Teaching Reading in the Elementary School (2-3)
450. Methods of Teaching Language Arts in Elementary School (3)

541. Children's Literature Related to Ethnic and Social Issues (3) Children's literature; K-12; study of literary symbolism, ethnic literature, and controversial issues; bibliotherapy, censorship, sex education through the trade book. Prerequisite: L.Ed. 441.

542. Seminar in English Language Arts (3) Topics in curriculum development and research in elementary and secondary English education and teacher training. Instructional materials analysis and development. Prerequisites: L.Ed. 442 or 443 and teaching experience.

543. Research Problems in the Teaching of English (3) Cooperative study by specialists, teachers, and administrators of problems and research findings in the teaching of English in American schools. Prerequisites: L.Ed. 442 or 443 and teaching experience.

MATHEMATICS EDUCATION (MTHED)

420. Teaching Mathematics in the Elementary Schools (3)
421. Teaching Mathematics in the Secondary Schools (4)
422. Individualizing Instruction in School Mathematics (3)
424. Contemporary Elementary School Mathematics Programs (3)
425. Contemporary Secondary School Mathematics Programs (3)
427. Computers and the Teaching of Mathematics (3)

520. Analysis of Research in Mathematics Education (3) Survey of the status of knowledge about mathematics learning and instruction, K-12; analysis of research procedures; instruments for evaluating research. Prerequisites: Mth.Ed. 420 or 421, 3 credits in statistics, and teaching experience.

521. Strategies for Research in Mathematics Education (3) In-depth analysis of strategies for research in mathematics education; conditions for applying the scientific model; implications for research and development. Prerequisite: Mth.Ed. 520.

525. Research Participation in School Mathematics Curriculum Construction (3) Development of theoretical bases for the construction of instructional materials in mathematics; research participation in preparing and testing curriculum materials. Prerequisite: Mth.Ed. 521.

SCIENCE EDUCATION (SCIED)

455. Field Natural History for Teachers (3)
456. Teaching of Conservation of Natural Resources in the Schools (3)
457. Teaching of Conservation of Natural Resources in the Elementary School (3)
458. Teaching Science in the Elementary School (3)
459. Teaching Science in the Secondary School (4)

556. The Supervision of Science Curriculum (3) Supervision of elementary and secondary science teachers as they develop K-12 programs in the public schools. Prerequisites: 6 credits in science methods, 20 credits in science or equivalent and teaching experience.

557. (Biol. 557) WORKSHOP IN THE BIOLOGICAL SCIENCES (3) Projects designed for teachers of biology in the secondary schools.

558. RESEARCH PROBLEMS IN SCIENCE TEACHING (3) Problems and research dealing with curriculum, materials, evaluation, and supervision of science teaching and learning. Prerequisites: Sci.Ed. 458 or 459 and teaching experience.

559. ANALYSIS OF INSTRUCTION IN ELEMENTARY SCIENCE EDUCATION (3) Analysis of the history, issues, trends, and research in elementary science education. Prerequisites: teaching experience, 3 credits in elementary science methods, and 18 credits of science courses.

SOCIAL STUDIES EDUCATION (SS ED)

430. TEACHING SOCIAL STUDIES IN THE ELEMENTARY GRADES (2-3)
431. TEACHING SOCIAL STUDIES IN THE SECONDARY SCHOOLS (4)
432. THE SOCIAL SCIENCES IN THE SOCIAL STUDIES CURRICULUM (2-3)

530. INSTRUCTIONAL PRACTICES IN THE SOCIAL STUDIES (3) Social studies innovations in the classroom, new programs, new materials, new methods, and evaluation. Prerequisite: one year of teaching experience.

531. PROBLEMS IN ELEMENTARY SCHOOL SOCIAL STUDIES (3) Historical-philosophical bases for the social studies: curriculum development, research findings and techniques, learning resources, and promising proposals. Prerequisites: 400-level course in social studies methods and elementary school teaching experience.

532. RESEARCH PROBLEMS IN SECONDARY SCHOOL SOCIAL STUDIES (3) Rationale of the social studies curriculum for the middle and high school. Promising social studies programs for the adolescent. Prerequisites: a methods course in social studies and teaching experience.

533. RESEARCH IN THE TEACHING OF SOCIAL STUDIES (3) Procedures and methods of research for the teaching of social studies, strategies of investigation and review of research literature. Prerequisites: 12 credits in the social sciences on the 400 or 500 level and teaching experience.

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1974-1975

The Pennsylvania State University Bulletin

Graduate Degree Programs

1974-1975

THE PENNSYLVANIA STATE UNIVERSITY

GRADUATE DEGREE PROGRAMS

GENERAL CATALOG ISSUE

SEPTEMBER 1974



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GRADUATE CALENDAR*

FALL TERM 1974

AUGUST 1974

5 Monday — Last Date for a Prospective Graduate Student to Submit Completed Application Materials for Admission to the Fall Term 1974

5 Monday — Last Date for a Graduate Student to Apply for Permission to Resume Study in the Fall Term 1974

SEPTEMBER

5-7 Thursday to Saturday — Pre-examination in German for Advanced Degree Candidates

5-7 Thursday to Saturday — Fall Term Registration

9 Monday — Fall Term Classes Begin 8:00 A.M.

13 Friday — Last Date for Registering with Foreign Language Departments (other than French and Spanish) for Written Language Examinations

23 Monday — Last Date for November Graduate to Pay Thesis Fees at Bursar's Office *and* to Activate Diploma Card in Registrar's Office

OCTOBER

1 Tuesday — Last Date for Written Foreign Language Examinations (other than French and Spanish) for Advanced Degree Candidates

5 Saturday — Last Date for a November Graduate to Deliver Doctoral Thesis to Committee

12 Saturday — Written French and Spanish Language Examinations for Advanced Degree Candidates**

12 Saturday — Last Date for Final Oral Doctoral Examinations for November Graduates

12 Saturday — Last Date for a November Graduate to Deliver Master's Thesis or Paper to Adviser

28 Monday — Last Date for a November Graduate to Deliver Thesis to Graduate School Office

28 Monday — Last Date for Departments to Certify to Graduate School Completion of Required Papers for November Graduates

28 Monday — Last Date for a November Graduate to Order Cap, Gown, and Hood Locally

NOVEMBER

16 Saturday — Last Date for Submitting a Petition to the Graduate Dean to Graduate in Absentia in November

16 Saturday — Fall Term Classes End 12:25 P.M.

18-20 Monday to Wednesday — Final Examinations

30 Saturday — Commencement

---

*This calendar was approved on October 2, 1972, and is subject to change without notice. In preparing the calendar for an academic year, the University makes every effort to avoid conflicts with religious holidays. However, such conflicts are sometimes unavoidable. When they occur, efforts are made to make special arrangements for the students affected.

**Students who plan to take examinations in French and Spanish should contact the University administrator of these tests, Professor A. V. Kozak, 166 Chambers Building, at least two weeks prior to the test date.

WINTER TERM 1975

NOVEMBER 1974

5 Tuesday — Last Date for a Prospective Graduate Student to Submit Completed Application Materials for Admission to the Winter Term 1975

5 Tuesday — Last Date for a Graduate Student to Apply for Permission to Resume Study in the Winter Term 1975

DECEMBER

3, 4 Tuesday, Wednesday — Pre-examination in German for Advanced Degree Candidates

3, 4 Tuesday, Wednesday — Winter Term Registration

5 Thursday — Winter Term Classes Begin 8:00 A.M.

16 Monday — Last Date for a March Graduate to Pay Thesis Fees at Bursar's Office *and* to Activate Diploma Card in Registrar's Office

21 Saturday — Winter Term Recess Begins 12:25 P.M.

JANUARY 1975

5 Sunday — Winter Term Recess Ends

6 Monday — Winter Term Classes Resume 8:00 A.M.

7 Tuesday — Last Date for Written Foreign Language Examinations (other than French and Spanish) for Advanced Degree Candidates

11 Saturday — Last Date for a March Graduate to Deliver Doctoral Thesis to Committee

18 Saturday — Last Date for Final Oral Doctoral Examinations for March Graduates

18 Saturday — Last Date for a March Graduate to Deliver Master's Thesis or Paper to Adviser

FEBRUARY

1 Saturday — Written French and Spanish Language Examinations for Advanced Degree Candidates*

3 Monday — Last Date for a March Graduate to Deliver Thesis to Graduate School Office

3 Monday — Last Date for Departments to Certify to Graduate School Completion of Required Papers for March Graduates

3 Monday — Last Date for a March Graduate to Order Cap, Gown, and Hood Locally

22 Saturday — Last Date for Submitting a Petition to the Graduate Dean to Graduate in Absentia in March

26 Wednesday — Winter Term Classes End 9:55 P.M.

27, 28 Thursday, Friday — Final Examinations

MARCH

1 Saturday — Final Examinations Continue

8 Saturday — Commencement

---

*Students who plan to take examinations in French and Spanish should contact the University administrator of these tests, Professor A. V. Kozak, 166 Chambers Building, at least two weeks prior to the test date.

SPRING TERM 1975

FEBRUARY 1975

11	Tuesday — Last Date for a Prospective Graduate Student to Submit Completed Application Materials for Admission to the Spring Term 1975
11	Tuesday — Last Date for a Graduate Student to Apply for Permission to Resume Study in the Spring Term 1975

MARCH

11, 12	Tuesday, Wednesday — Pre-examination in German for Advanced Degree Candidates
11, 12	Tuesday, Wednesday — Spring Term Registration
13	Thursday — Spring Term Classes Begin 8:00 A.M.
21	Friday — Last Date for Registering with Foreign Language Departments (other than French and Spanish) for Written Language Examinations
24	Monday — Last Date for a May Graduate to Pay Thesis Fees at Bursar's Office *and* to Activate Diploma Card in Registrar's Office

APRIL

5	Saturday — Last Date for a May Graduate to Deliver Doctoral Thesis to Committee
8	Tuesday — Last Date for Written Foreign Language Examinations (other than French and Spanish) for Advanced Degree Candidates
12	Saturday — Last Date for Final Oral Doctoral Examinations for May Graduates
12	Saturday — Last Date for a May Graduate to Deliver Master's Thesis or Paper to Adviser
14	Monday — Written French and Spanish Language Examinations for Advanced Degree Candidates*
28	Monday — Last Date for a May Graduate to Deliver Thesis to Graduate School Office
28	Monday — Last Date for Departments to Certify to Graduate School Completion of Required Papers for May Graduates
28	Monday — Last Date for a May Graduate to Order Cap, Gown, and Hood Locally

MAY

6	Tuesday — Annual Graduate Faculty Meeting
17	Saturday — Last Date for Submitting a Petition to the Graduate Dean to Graduate in Absentia in May
21	Wednesday — Spring Term Classes End 9:55 P.M.
22-24	Thursday to Saturday — Final Examinations
26	Monday — Memorial Day
31	Saturday — Commencement

*Students who plan to take examinations in French and Spanish should contact the University administrator of these tests, Professor A. V. Kozak, 166 Chambers Building, at least two weeks prior to the test date.

SUMMER TERM 1975

MAY 1975

12 Monday — Last Date for a Prospective Graduate Student to Submit Completed Application Materials for Admission to the Summer Term 1975

12 Monday — Last Date for a Graduate Student to Apply for Permission to Resume Study in the Summer Term 1975

JUNE

10 Tuesday — Pre-examination in German for Advanced Degree Candidates

10 Tuesday — Summer Term Registration

11 Wednesday — Summer Term Classes Begin 8:00 A.M.

20 Friday — Last Date for Registering with Foreign Language Departments (other than French and Spanish) for Written Language Examinations

23 Monday — Last Date for an August Graduate to Pay Thesis Fees at Bursar's Office *and* to Activate Diploma Card in Registrar's Office

28 Saturday — Written French and Spanish Language Examinations for Advanced Degree Candidates*

JULY

4 Friday — Independence Day Holiday

5 Saturday — Last Date for an August Graduate to Deliver Doctoral Thesis to Committee

8 Tuesday — Last Date for Written Foreign Language Examinations (other than French and Spanish) for Advanced Degree Candidates

12 Saturday — Last Date for Final Oral Doctoral Examinations for August Graduates

12 Saturday — Last Date for an August Graduate to Deliver Master's Thesis or Paper to Adviser

28 Monday — Last Date for an August Graduate to Deliver Thesis to Graduate School Office

28 Monday — Last Date for Departments to Certify to Graduate School Completion of Required Papers for August Graduates

28 Monday — Last Date for an August Graduate to Order Cap, Gown, and Hood Locally

AUGUST

16 Saturday — Last Date for Submitting a Petition to the Graduate Dean to Graduate in Absentia in August

20 Wednesday — Summer Term Classes End 9:55 P.M.

21-23 Thursday to Saturday — Final Examinations

30 Saturday — Commencement

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*Students who plan to take examinations in French and Spanish should contact the University administrator of these tests, Professor A. V. Kozak, 166 Chambers Building, at least two weeks prior to the test date.

FALL TERM 1975

AUGUST 1975

4 Monday — Last Date for a Prospective Graduate Student to Submit Completed Application Materials for Admission to the Fall Term 1975

4 Monday — Last Date for a Graduate Student to Apply for Permission to Resume Study in the Fall Term 1975

SEPTEMBER

3-5 Wednesday to Friday — Pre-examination in German for Advanced Degree Candidates

3-5 Wednesday to Friday — Fall Term Registration

8 Monday — Fall Term Classes Begin 8:00 A.M.

12 Friday — Last Date for Registering with Foreign Language Departments (other than French and Spanish) for Written Language Examinations

22 Monday — Last Date for a November Graduate to Pay Thesis Fees at Bursar's Office *and* to Activate Diploma Card in Registrar's Office

30 Tuesday — Last Date for Written Foreign Language Examinations (other than French and Spanish) for Advanced Degree Candidates

OCTOBER

4 Saturday — Last Date for a November Graduate to Deliver Doctoral Thesis to Committee

11 Saturday — Written French and Spanish Language Examinations for Advanced Degree Candidates*

11 Saturday — Last Date for Final Oral Doctoral Examinations for November Graduates

11 Saturday — Last Date for a November Graduate to Deliver Master's Thesis or Paper to Adviser

25 Saturday — Last Date for a November Graduate to Deliver Thesis to Graduate School Office

25 Saturday — Last Date for Departments to Certify to Graduate School Completion of Required Papers for November Graduates

25 Saturday — Last Date for a November Graduate to Order Cap, Gown, and Hood Locally

NOVEMBER

15 Saturday — Last Date for Submitting a Petition to the Graduate Dean to Graduate in Absentia in November

15 Saturday — Fall Term Classes End 12:25 P.M.

17-19 Monday to Wednesday — Final Examinations

29 Saturday — Commencement

*Students who plan to take examinations in French and Spanish should contact the University administrator of these tests, Professor A. V. Kozak, 166 Chambers Building, at least two weeks prior to the test date.

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JAMES E. YSSELDYKE, Ph.D. (Illinois) *Assistant Professor of School Psychology*
FRANKLIN R. ZABRISKIE, Ph.D. (Princeton) *Associate Professor of Astronomy*
JOSEPH ZAFFORONI, Ed.D. (Columbia) *Professor of Education*
SAM Y. ZAMRIK, Ph.D. (Penn State) *Associate Professor of Engineering Mechanics*
ARIAN ZARKOWER, Ph.D. (Cornell) *Associate Professor of Veterinary Science*
WILBUR ZELINSKY, Ph.D. (California) *Professor of Geography*
JOHN H. ZIEGLER, JR., Ph.D. (Penn State) *Associate Professor of Meat Science*
VICKIE L. ZIEGLER, Ph.D. (Yale) *Assistant Professor of German*
LEONARD N. ZIMMERMAN, Ph.D. (Cornell) *Professor of Bacteriology*
RICHARD E. ZINDLER, Ph.D. (Michigan State) *Professor of Engineering Research*
HARRY D. ZOOK, Ph.D. (Penn State) *Professor of Chemistry*
GEORGE S. ZORETICH, M.A. (Penn State) *Professor of Art*

GENERAL INFORMATION

THE GRADUATE SCHOOL

Graduate work at The Pennsylvania State University was first offered in 1862, but for some time there were few graduate students and graduate instruction was relatively unorganized. A committee of the General Faculty eventually was given the responsibility of establishing standards and regulations governing graduate work and the granting of master's and certain technical degrees. The Graduate School was formally established in 1922 by the President and the Board of Trustees. An administrative staff was organized, and the Graduate Faculty was formed. The University Senate delegated to this faculty responsibility for graduate affairs, subject to review. In 1924 the Board of Trustees authorized the granting of the degree of Doctor of Philosophy. On May 9, 1971, a Graduate Council was established for the Graduate School. Today graduate study is offered in 126 major programs, with 16 advanced academic and professional degrees being conferred. During the academic year 1973-1974, 5,800 to 6,200 graduate students were enrolled each term, and 1,971 advanced degrees were conferred, of which 377 were doctorates.

The Graduate School maintains close contact with other graduate schools in order to keep abreast of developments in graduate education throughout the country. It is a member of the Association of Graduate Schools (an organization within the Association of American Universities) and of the Council of Graduate Schools in the United States.

MAJOR ROLE

The major role of the Graduate School is to emphasize those aspects of University activity which pertain directly to major programs in graduate study. Through its Graduate Faculty it represents a large segment of the academic strength of the University and is thus a dominant force in sustaining and furthering the intellectual quality of the entire institution. The eleven Colleges formulate study and research programs appropriate to their fields. The Graduate Faculty consists of those members of the College faculties who have authorization through the Graduate School to offer courses and seminars and supervise research and theses consistent with the highest academic standards. Thus, the Graduate School may be regarded as a federation of selected segments of the College faculties.

GOVERNANCE

The governance of the Graduate School is vested in a Graduate Council, whose legislative authority is subject to the specific restrictions of the "Articles of Authority." The Council forms its own committee structure under bylaws outlined in "Standing Rules of the University Graduate Council." A summary of actions taken by the Council is published in the *Senate Record.*

Executive and administrative matters of the Graduate School are the responsibility of the Dean, who is charged directly with enforcement of the regulations of the Graduate School and with organization of its administrative procedures. The Dean has a major responsibility to enhance and insure the high quality of graduate study and research of graduate students on the University Park Campus and at other locations where such graduate work is conducted. He exercises leadership in initiating new programs and in restructuring or phasing out marginal and obsolete ones. The Dean encourages and assists in the development of multidisciplinary programs. He is assisted in this work by an administrative and clerical staff.

ADMINISTRATIVE DIVISIONS

There are four major administrative divisions in the Graduate School to which the students may go directly for answers to the questions which require administrative assistance or decisions:

1. *Graduate Admissions,* 310 Kern Graduate Building. The Office of Graduate Admissions has responsibility for processing all matters pertaining to a student's admission.
2. *Graduate Student Programs,* 211 Kern Graduate Building. The functions of the Office of Graduate Student Programs encompass responsibilities for the academic involvement and concerns of all graduate students from the time they are admitted until they graduate, such as: (a) registration of students, (b) readmission of students, (c) maintenance of records, (d) appointment of graduate committees for doctoral students, (e) scheduling of graduate student comprehensive examinations, (f) checking for accomplishment by students of Graduate Faculty requirements for all advanced degrees and preparation of official commencement lists, and (g) attention to student academic problems.
3. *Graduate Fellowships,* 317 Kern Graduate Building. The Office of Graduate Fellowships serves as a clearinghouse for information on available fellowships and other awards for graduate students, administers fellowships and other award programs involving students in more than one college, and seeks support for graduate students attending the University.
4. *Theses and Publications,* 320 Kern Graduate Building. The Office of Theses and Publications is responsible for reviewing all theses to meet Graduate School specific format requirements consistent with the attainment of high scholarly standards. The office prepares, arranges for publication, and provides source materials through the major Graduate School publications.

PROGRAMS AT OTHER LOCATIONS

Behrend Graduate Center — The Behrend Graduate Center at Erie opened with the winter term, January 1969, and provides convenient opportunity for graduate education to persons residing in northwestern Pennsylvania. It has been established to offer individual courses and a program leading to the degree of Master of Engineering with a major in engineering science.

King of Prussia Graduate Center — The King of Prussia Graduate Center near Philadelphia opened in 1963. Its programs lead to the degrees of Master of Engineering with majors in engineering science and industrial engineering, and Master of Education with a major in mathematics.

The Capitol Campus — The Capitol Campus, located near Middletown and named for its proximity to the state capitol, was opened in 1966. Graduate programs leading to the degrees of Master of Administration, Master of Arts with majors in American studies and in humanities, Master of Education with a major in elementary education, Master of Engineering with a major in engineering science, Master of Psychosocial Science, Master of Public Administration, and Master of Regional Planning are currently offered.

The Milton S. Hershey Medical Center — The University's Medical Center was established in 1963, and the first class of medical students entered in the fall of 1967. The Center is located in Hershey, Pennsylvania, twelve miles from Harrisburg. In conjunction with The Pennsylvania State University's Graduate School, the College of Medicine offers programs leading to the Master of Science degree with a major in laboratory animal medicine, and to the Doctor of Philosophy and Master of Science degrees with majors in anatomy, biological chemistry, genetics, microbiology, pharmacology, and physiology.

COOPERATIVE ARRANGEMENTS WITH OTHER INSTITUTIONS

A working arrangement has been established with Jefferson Medical College of Philadelphia whereby a candidate for an advanced degree at Jefferson may do part of his graduate work at The Pennsylvania State University by scheduling relevant courses and research at University Park. Similarly, a graduate student with an appropriate major at The Pennsylvania State University may earn credits at Jefferson which, with advance approval by his major department

or program, will be accepted in partial fulfillment of degree requirements at The Pennsylvania State University.

KERN GRADUATE BUILDING

The graduate building opened in February 1971 and was officially dedicated on March 16, 1971. It has since been officially named the Kern Graduate Building in honor of the late Dean Emeritus Frank D. Kern, who was the first Dean of the Graduate School. The Graduate School administrative offices are housed on the second and third floors of the building.

GRADUATE COMMONS

The Graduate Commons is located on the first floor of the Kern Graduate Building and provides facilities for the entire Graduate School community and a common meeting ground for faculty and students. The assembly room and multipurpose rooms are used for large group meetings; the smaller rooms are used for seminars and doctoral oral examinations.

Food service is provided in the cafeteria. The lobby is available for display of art work done by students and faculty and from outside galleries. Exhibits are normally displayed for two weeks.

The Office of the Graduate Commons Manager serves as a clearinghouse for the scheduling of events planned by organizations and individuals.

GRADUATE STUDENT ASSOCIATION

The Graduate Student Association was established in 1951 as the official voice of graduate students, all of whom are automatically members. It is the particular function of the organization to give to the individual member the opportunity to stimulate student intellectual interests and to bring to light problems and resolve them through discussion and collective action. It provides the occasion for relaxation through its social program. The University allocates an appropriation to the Association to help defray expenses.

The Graduate Student Association Council, the legislative arm of the Association, consists of elected delegates from every graduate department with voting rights proportionate to the number of students in the department. Also included as voting *ex officio* members are the graduate students who have been elected to serve on the University Faculty Senate (4), the Graduate Council (5), and the University Council (1). All members of the University community are invited to attend the regular monthly meetings of the Association Council. An Executive Board, which consists of the executive officers and division heads, has interim powers to conduct business not requiring the specific action of the Association Council. The executive officers act as official liaison between the Association and the Dean of the Graduate School.

The Graduate Student Association has an office in 305 Kern Graduate Building, where it maintains its records and conducts its business. It has established the following divisions and standing committees: *Service Division* (1) Housing Committee, (2) Publication Committee, (3) Health Committee, (4)Tax Committee, and (5) Orientation Committee; *Programming Division* (1) Coffeehouse Committee, (2) Film Committee, (3) Speaker's and Workshop Committee, and (4) Special Events Committee; *Academic Division* (1) University Faculty Senate Graduate Student Caucus, (2) Graduate Council — Graduate Student Caucus, (3) University Council — Graduate Student Caucus, and (4) Academic Affairs Committee; and *Rules Committee.*

In addition, the Association Council may institute *ad hoc* committees and presidential commissions at will. Graduate students are eligible to serve on all committees of the Graduate Council.

The Association maintains communication among its members through the campus daily newspaper, its own newsletter, scheduled meetings and workshops, and informal use of the Graduate Commons.

FACILITIES

THE UNIVERSITY LIBRARIES

The University Libraries include a central collection, six special libraries, and one reading room at University Park; the library at Hershey Medical Center; the King of Prussia Graduate Center Library; the Capitol Campus Library; and libraries at each of the seventeen Commonwealth Campuses and at Behrend College.

At University Park, the central collection, the Undergraduate Library, the Arts Library, and the Agricultural and Biological Sciences Library are all housed in the Fred Lewis Pattee Library Building. There are four branch libraries serving the Colleges of Earth and Mineral Sciences, Engineering, and Science, and the Department of Mathematics; one reading room in the Department of Architecture; and two branch Undergraduate Libraries in dormitory areas.

Included in the central collection are general reference books and periodicals, works in agriculture, biology, education and psychology, economics and business, the humanities, the natural and social sciences, maps, manuscripts, and documents. Among special collections are the Penn State Collection, a Joseph Priestley and a John O'Hara Collection, labor history archives, Australiana and Utopian literature, the Allison-Shelley Collection of Anglica Americana Germanica, music cassettes, and a rare book collection. Housed in Pattee Library is the Penntap Information System which serves industries, municipalities, and businesses in the Commonwealth. In the reading room and special branch libraries are books and journals needed for work assigned in the Colleges mentioned above. The Library has issued a library handbook for students.

The University Libraries are a member of numerous cooperative groups. They are one of the four Regional Library Resource Centers as established by Pennsylvania law and have memberships in the Union Library Catalogue of Pennsylvania, the Association of Research Libraries, the Mid-Atlantic Research Libraries Information Network, the Area College Library Cooperative Program of Central Pennsylvania, and the Pittsburgh Regional Library Center.

In 1973 a 133,000-square-foot building adjoining Central Pattee was completed. Known as East Pattee, this structure contains five floors which include some public service areas, technical operations, and administration. The Libraries have approximately 1,600,000 catalogued volumes, 750,000 documents, 14,000 periodicals, and about 1,600,000 other bibliographical items including microforms. Among the special resource guides issued by the Library are *Newspapers in Microform* and *Pennsylvania Maps and Atlases.*

COMPUTATION CENTER

The Computation Center aids in the education and research programs of all academic departments. Its facilities are open to graduate students and faculty engaged in research and to students doing class assignments. Its equipment includes two large IBM computers, an ADAGE AGT-30, a 1401, and several small peripheral machines. The System/370 Model 165 has two and one-half million bytes of fast core storage, 800 million bytes of disk and drum storage, and a large configuration of input/output equipment. Access to the Model 165 can be obtained through high-speed batch terminals located on the main campus or through medium-speed batch terminals located at the Commonwealth Campuses. The System/360 Model 50 is about one-half the size of the Model 165 and is devoted to time-sharing services. Several access stations, providing instant turnaround for short jobs, are available for students first learning to use a computer. Typewriter terminals may access to either the Model 50 APL/360 time-sharing system or the Model 165 remote job entry facility using the dial telephone network. A well-equipped ADAGE AGT-30 Computer Graphics System allows extensive graphics work. An interface to the Model 165 further extends its graphics capability.

The Computation Center staff conducts workshops to acquaint graduate students and faculty with its services. A student who will need the Center's facilities should attend these workshops and should consult the staff early in his research so that a program can be worked out for his project and his work scheduled without delay. Programming consultants in the Center provide advice and assistance in using library programs prepared by the Center and in programming and checking out new applications. The facilities of the Computation Center are widely used

for instruction and research in most academic departments at no charge to the student. The King of Prussia Graduate Center, the Capitol Campus, The Milton S. Hershey Medical Center, the Behrend College, and most of the Commonwealth Campuses have remote batch terminals which permit processing of computer jobs at the central computer equipment operated by the Computation Center at University Park.

OTHER FACILITIES

The University offers many additional facilities which are available to students through their major programs of study.

LIVING ACCOMMODATIONS

Eastview Terrace and Graduate Circle, both located on the eastern side of the campus, and within comfortable walking distance of most of the campus, provide one- and two-bedroom apartments for married graduate students.

The Eastview Terrace apartments are fire-resistant, steel framework, one-story buildings. There are forty-six one-bedroom units ($85 per month) and thirty-two two-bedroom units ($95 per month). Rent includes utilities except for electricity, telephone, and TV cable. Water is heated electrically. The units are unfurnished except for electric stove and refrigerator. For each two units, there is a utility room with two stationary laundry tubs and storage space. Privately owned automatic washers may be installed in apartment kitchens only. No coin-operated facilities are available.

Graduate Circle has 144 one-bedroom apartments ($95 per month) and 72 two-bedroom apartments ($105 per month) in sixteen two-story buildings of brick and frame construction. Rent includes all utilities except for telephone and TV cable. Each kitchen has a double stainless steel sink with disposal unit, a gas stove, kitchen cabinets, and an electric refrigerator. One bedroom has a built-in chest of drawers; otherwise, the units are unfurnished. There are no facilities for private washing machines in the apartments; however, coin-operated laundries at nominal fees are provided in five of the buildings throughout the area. A basement storage locker is provided for each apartment.

Residence in Graduate Circle or Eastview Terrace Married Graduate Student Apartments is limited to registered full-time graduate students who are candidates for advanced degrees. All students must be married and must live with their spouse in the apartment. Families with children of school age (including kindergarten) or with children who will come of school age during the term of the lease cannot be considered for occupancy. The one-bedroom units are designed for a husband and wife, and the two-bedroom units for a family with not more than two children. Length of residency in married graduate student housing is normally limited to three calendar years.

Atherton Hall, located near the Hetzel Union Building, and McKee Hall, located near the Kern Graduate Building, are residence halls reserved exclusively for single graduate men and women, which provide room accommodations without food service. Most assignments of new applicants are made to double rooms ($171 per term), since single rooms are available for only one out of every three students.

The Hetzel Union Building and Graduate Commons cafeterias and snack bars are available for meals. Separate dining hall meal tickets for one of the eight campus dining halls may be purchased for the term at an approximate cost of $257. Twenty-one meals per week are served, beginning with registration and ending with final examinations.

For additional information on living accommodations and meal tickets, contact the Assignment Office for Campus Residences, 101 Shields Building, University Park, Pa. 16802. Telephone: (area code 814) 865-7501.

Information on other living accommodations available in the community may be obtained through:

The Graduate Student Association
305 Kern Graduate Building
The Pennsylvania State University
University Park, Pennsylvania 16802
Phone: (814) 865-9061

The Organization of Town Independent Students
20 Hetzel Union Building
The Pennsylvania State University
University Park, Pennsylvania 16802
Phone: (814) 865-6851

The State College Area Chamber of Commerce
129 West Beaver Avenue
State College, Pennsylvania 16801
Phone: (814) 237-7644

Graduate students should arrange for their accommodations well in advance of the beginning of classes, because it may be very difficult to find convenient housing at the last minute. STUDENTS MUST BE ADMITTED TO THE GRADUATE SCHOOL BEFORE THEIR REQUESTS FOR ON-CAMPUS LIVING ACCOMMODATIONS CAN BE PROCESSED.

STUDENT SERVICES

The facilities and services outlined in the following paragraphs are available to graduate students and, in cases of emergency, to the graduate student's spouse and dependents.

UNIVERSITY HEALTH SERVICES

Located in the central campus area, the Ritenour Health Center is the core of the health service activities and is composed of a dispensary and a hospital. Its facilities are available to full-time graduate students, that is, students registered for 8 or more credits or the equivalent (students holding quarter-time assistantships scheduling 7 to 9 credits, or students holding half-time assistantships scheduling 5 to 7 credits)*. The outpatient dispensary handles student medical problems from 8:00 a.m. to 11:45 a.m. and from 1:30 p.m. until 4:45 p.m. daily except Saturdays, when hours are from 8:00 a.m. to 11:45 a.m. During other periods, including Sundays and holidays, patients are seen for emergencies only in the Emergency Room of the University Hospital, which is part of the Health Center complex.

The University Hospital is well equipped to handle the more serious illnesses and injuries on an inpatient basis. A fifty-bed facility, it is staffed with professional personnel twenty-four hours a day during the school terms. Should the need arise for special medical or surgical treatment — major surgery, for example — the student is transferred to a hospital facility of his choice.

Included in the Health Center facilities are a dental office for emergency dental care, a physiotherapy department, and a pharmacy.

Hospitalized students will be charged $10 per day during confinement, and a nominal charge will be made for all drugs dispensed to hospital or dispensary patients. A standard laboratory and X-ray fee is charged for examinations done in the Health Center when ordered by physicians other than the members of the Health Center staff. Consultation with or treatment by physicians other than the professional staff at the Health Center is at the student's expense.

The Ritenour Health Center maintains an ambulance service for local transportation of students with nonambulatory illnesses and injuries.

*Eligibility is determined by the Graduate School when the I.D. cards are issued.

HEALTH INSURANCE PLAN

The University has arranged for a voluntary group Student Accident and Sickness Insurance Plan with a variety of benefits available to graduate students and their dependents, provided the student is eligible for the services of the Ritenour Health Center and pays the cost of the policy and the appropriate premium for the inclusion of dependents.

The plan is set up on a school year basis beginning with the fall term. At this time a representative of the insurance company maintains an enrollment desk in the Hetzel Union Building. An open enrollment is also held near the beginning of the spring term for coverage until the fall term.

Included in the plan is coverage for accidental death or accident medical benefits, hospitalization, laboratory fees, surgery, and doctors' visits up to fixed amounts, plus major medical expense benefits after satisfaction of $100 deductible for each illness. This plan also provides a major medical expense benefit only, but requires the insured to pay the first $500 as a result of sickness or accident.

Full details are available each year through the representative at Hetzel Union Building or through the local representative (telephone area code 814, 238-6725).

MEDICAID BENEFITS

Graduate students can qualify for most of the benefits that apply to hospitalization and medical treatment under Medicaid. State medical assistance is available upon application to the Office of the Centre County Board of Assistance, Bellefonte, Pa. 16823.

HEALTH SERVICES FOR CHILDREN

Many medical services are available for children under 21 through the State Health Center. The services range from simple immunizations to complicated surgery. Diagnostic study and consultation at the Center are made regardless of the ability to pay. Children may be referred to the Center by physicians or health and welfare agencies. Since many of the services require continual consultation with the physician, referrals must be by physicians located in Centre County. For additional information, consult your doctor, or contact the Health Center at 110 South School Street, Bellefonte, Pa. 16823.

INSURANCE PROTECTION WHILE ATTENDING THE UNIVERSITY

The Pennsylvania State University is an instrumentality of the Commonwealth performing its function of education. It is not liable for the negligence of its officers, servants, and employees when in the exercise of public or governmental powers or in the performance of public or governmental duties incident to the general education work of the University.

Therefore, any student who desires insurance protection while in attendance at the University against personal injury and/or against loss of property by fire or theft should arrange personally for whatever insurance seems advisable.

CAREER DEVELOPMENT AND PLACEMENT CENTER

The center functions as both a counseling and placement service for students. Its primary purpose is to serve students, both individually and in groups, by assisting them through career and educational counseling in formulating immediate and long-range career plans.

The center cooperates with the Colleges and departments of the University to assist students in implementing career plans upon graduation. Services include: (1) a library containing information on career opportunities, employer characteristics, and graduate and professional schools; (2) scheduled interviews with prospective employers who are visiting the campus; (3) a file of employment opportunities for which a student may apply by mail; (4) a listing of career-related summer jobs and internships; (5) workshops in interviewing skills and techniques; (6) a variety of informational meetings and publications; and (7) credential services for candidates seeking positions in educational institutions.

TUITION AND CHARGES

The University reserves the right to revise the schedule of tuition and charges without further notice.

TOTAL TUITION FOR EACH TERM

University Park Campus and Medical Center (Nonmedical Students) — 8 or more credits, total charge of $320 for Pennsylvanians and $720 for non-Pennsylvanians; 7 or fewer credits, $40 per credit for Pennsylvanians and $91 for non-Pennsylvanians. (Medical Students) — 8 or more credits, total charge of $500 for Pennsylvanians and $1,000 for non-Pennsylvanians; 7 or fewer credits, $62 per credit for Pennsylvanians and $125 for non-Pennsylvanians. These rates apply also to off-campus research and other approved individual study.

Graduate Centers and Capitol Campus — 8 or more credits, total charge of $305 for Pennsylvanians and $720 for non-Pennsylvanians; 7 or fewer credits, $35 per credit for Pennsylvanians and $91 for non-Pennsylvanians.

Continuing Education Centers — University Park, $40 per credit for Pennsylvanians and $91 per credit for non-Pennsylvanians; Graduate Centers and Capitol Campus, $35 per credit for Pennsylvanians and $91 per credit for non-Pennsylvanians.

Vocational Education Program — 8 or more credits, total charge of $320 for Pennsylvanians and $720 for non-Pennsylvanians; 7 or fewer credits, $40 per total program for all students (vocational education courses are indicated by "v" following the course number).

Tuition is the same for courses whether audited or taken for credit.

Any student who does not fulfill payment obligations promptly may be charged a late payment fee of $25. A student whose account is delinquent for more than ten days is subject to suspension from the University.

Whenever it appears that an applicant for admission is not domiciled in Pennsylvania, it is assumed that he is a non-Pennsylvanian. If the student who is thus admitted believes that his circumstances do not justify his classification as a non-Pennsylvanian, he may petition the Financial Officer for the Dean of the Graduate School, 316 Kern Graduate Building, University Park, Pa. 16802, for reclassification. (See Student Pennsylvania Resident Status, page 60.)

TUITION REFUND POLICY

Charges for tuition are refundable upon withdrawal from the University only in the event the student obtains an Official Withdrawal Form at the Office of the Dean of the Graduate School and presents it, together with his current Certificate of Registration, at the Office of the Fee Assessor no later than one calendar month after the effective date of withdrawal from classes. Students who meet these conditions are entitled to receive refunds of charges for tuition for the term in accordance with the following schedule:

> Refund of 80 percent upon withdrawal before the end of the first week of the term (seventh consecutive calendar day from the first day of classes) and a decrease of 20 percent for each week thereafter up to and including the fourth consecutive calendar week. No amount will be refunded for withdrawal after the fourth consecutive calendar week of the term.

The University will not release any refund of tuition until at least three weeks have elapsed from the date the payment was received. All refunds will be made by check and mailed to the student's home address.

SPECIFIC CHARGES

In addition to the foregoing tuition and charges, the following charges apply under special conditions and are to be paid independently:

Application fee	$15.00
Change of schedule, each change	2.00

Duplicate meal ticket	1.00
Duplicate student identification and activity card	each 4.00
French reading examination	6.00
Music, individual lessons	30.00 to 100.00
Privilege of late payment	25.00
Privilege of late registration	10.00
Special Ph.D. thesis preparation registration fee (601, 611)	100.00
Student parking fee, each term	10.00
Teacher placement service registration fee	5.00
Teacher placement service reactivation fee	5.00
Thesis microfilming and binding fee for master's candidate	10.50
Thesis microfilming and binding fee for doctoral candidate	45.50
Transcript of records (with seal), each copy	1.00
Mailing diploma in absentia	5.00

MOTOR VEHICLE CHARGES

Each graduate student who possesses, maintains, or operates a motor vehicle (including a motorcycle, motor bike, motor scooter, or any other motor-driven vehicle) while at the University is required to register such vehicle with the Traffic Violations Officer during the registration period of each term. There is no registration charge for students who do not desire campus driving or parking privileges. Failure to register a vehicle renders a student liable for a fine of $15 for each offense.

A permit allowing limited driving and parking on the campus throughout the week costs $10 per term. A more restricted permit allowing driving and parking on the campus for evenings and weekends costs only $3.50 per term.

A graduate assistant pays no fee for the privilege of driving and parking on the campus but is required to comply with student regulations concerning motor vehicles. A graduate assistant receiving no fee decals must present the owner's card for the vehicle each term. If a student lives for more than thirty consecutive days of the year in Pennsylvania, he shall be required to obtain Pennsylvania registration for his vehicle. A student's spouse may be required to register his or her car in Pennsylvania. A *Student Parking and Traffic Regulations* booklet is available in Room 209 Hetzel Union Building.

Bicycles — A bicycle is defined as a two-wheeled vehicle propelled by human power. Bicycle registration is located at 126 Grange Building, Police Services. Registration is available 24 hours a day at no cost. Rules and regulations are available at the time of registration.

STUDENT AIDS

In every case in which a graduate assistantship, fellowship, grant-in-aid, or scholarship for the next academic year is offered to an actual or prospective graduate student, the student, if he indicates his acceptance before April 15, will have complete freedom through April 15 to submit in writing a resignation of his appointment in order to accept one elsewhere. However, an acceptance given or left in force after April 15 commits him not to accept another appointment without first obtaining formal release for the purpose.

ASSISTANTSHIPS

Approximately 2,100 graduate assistantships are awarded annually. Most of these are half-time, but a limited number of quarter-time and three-quarter-time assistantships are available in some major programs. An appointee may serve as an assistant in classroom or laboratory instruction, or in research or other work.

A prospective student should write directly to the head of his major department or program chairman for information and application forms. Appointments are made upon the recommendation of the department head or program chairman, subject to the student's admission to the

Graduate School as a degree candidate. Clear evidence of superior ability and promise is required. Reappointment to an assistantship is based on availability of positions and the quality of the student's work. In most departments or major programs the number of appointment renewals is limited. A common policy is to limit eligibility to two calendar years of study for a master's candidate or five total years for a doctoral candidate.

The assistantships vary as follows:

QUARTER-TIME — The student may schedule 7-9 credits, receives a stipend in the range $339-$630 per term plus a grant-in-aid which covers tuition, will be assigned tasks occupying a maximum of ten hours of service per week for twelve weeks, and will be considered to be following a full-time course of instruction.

HALF-TIME — The student may schedule 5-7 credits, receives a stipend in the range $672-$1,260 per term plus a grant-in-aid which covers tuition, will be assigned tasks occupying a maximum of twenty hours of service per week for twelve weeks, and will be considered to be following a full-time course of instruction.

THREE-QUARTER-TIME — The student may schedule 4-5 credits, receives a stipend in the range $1,011-$1,890 per term plus a grant-in-aid which covers tuition, will be assigned tasks occupying a maximum of thirty hours per week for twelve weeks, and will be considered a part-time student.

The credit load limits specified above may be increased or decreased for a specific term by permission of the person to whom the student is responsible for his service assignment, provided the credit load and the service load are properly balanced in each term, and the total credit load over a series of terms is in conformity with the specified limits stated above.

In addition to receiving a grant-in-aid to cover full tuition during the term of appointment, a graduate assistant who is completing three or more consecutive terms of appointment is entitled to apply for an extra earned grant-in-aid to cover tuition for the succeeding term if he is not receiving a scholarship or fellowship from another source during the term. To receive this privilege a student must obtain an extra earned grant-in-aid form from the head of the department or program in which he has held the assistantship and must follow the instructions on the form in making application.

A graduate assistant may accept concurrent employment outside the University only with the permission from the department head or program chairman. He may not hold concurrent employment with the University. He may receive a concurrent fellowship supplement.

A graduate assistant pays no fee for the privilege of driving and parking on the campus but is required to comply with student regulations concerning motor vehicles.

FELLOWSHIPS AND TRAINEESHIPS

More than three hundred fellowships and traineeships are awarded annually. Recipients must be superior students and are frequently required to have completed a certain minimum of graduate work before being eligible for an award. Need is also normally a consideration. Fellows and trainees carry full-time graduate programs, receive stipends which vary with the awards, and receive grants-in-aid paid by the donors of the awards to provide for all tuition. They may not accept employment during the terms of their appointments (except with special permission for training purposes), nor are they required to render any service to the University. In some cases a recipient will be expected to limit his research to a broad field specified by the donor. Recipients are required to pay specific charges, such as admission, late registration, change of schedule, and parking fees, and also the thesis binding and microfilming fee unless the latter is paid for by the donor of the award.

COMMONWEALTH OF PENNSYLVANIA RESEARCH FELLOWSHIPS — Intended as a means of encouraging students to conduct research on projects of special application to Pennsylvania, awardees are selected from among Ph.D. candidates who will have passed their comprehensive examination before the start of fellowship tenure on the basis of the usefulness of their research to Pennsylvania, on scholarly promise, and on need. These fellowships pay up

to $300/month for three to twelve months plus remission of the dissertation fee. Application forms are available in Room 317 Kern Graduate Building.

GRADUATE SCHOOL FELLOWSHIPS — A number of fellowships, each paying a stipend of up to $285/month and providing a grant-in-aid to cover tuition charges, are given by the University and are designated as Graduate School Fellowships. They are available to outstanding graduate students working toward an M.F.A. degree or a degree in any doctoral program, although, ability of applicants being comparable, some preference is given to students majoring in the humanities and social sciences.

Application forms may be obtained from the Graduate School Fellowship Office, 317 Kern Graduate Building. Applications must be submitted through the applicant's department or program and must be received by the Graduate School by the first Monday in February to be considered for the following year.

ERIC A. WALKER FELLOWSHIPS, FELLOWSHIP SUPPLEMENTS, AND GRANTS-IN-AID — These are open only to students who have been approved for admission but are not yet enrolled in the Graduate School at the time of application. Full fellowships pay up to $265/month plus tuition. Grants-in-aid provide only tuition. Supplements are small grants in addition to a graduate assistantship or another fellowship. Some supplements are in the form of low-interest loans. Application forms may be obtained from the Fellowship Office, 317 Kern Graduate Building, University Park, Pa. 16802, and must be submitted by mid-February to be considered for the following fall. Applicants must arrange to have Graduate Record Examination verbal and quantitative scores sent to this address so as to reach the Fellowship Office by the application deadline.

FELLOWSHIPS AND TRAINEESHIPS FROM SPECIFIC GRANTS TO DEPARTMENTS AND DIVISIONS BY FOUNDATIONS, INDUSTRIES, AND FEDERAL AGENCIES — At least 230 such awards, with various stipends, are granted through individual departments. Information and application forms may be secured from the head of the major department concerned. The specific awards will vary somewhat from year to year, but the following are typical of those which were available for 1972-73.

AMELIA EARHART FELLOWSHIP — Available to a woman graduate student in aerospace engineering; stipend $2,400.

AMERICAN CHEMICAL SOCIETY FELLOWSHIPS (2) — Available to a graduate student in chemical engineering; stipend $2,988.

AMERICAN CHEMICAL SOCIETY FELLOWSHIPS (2) — Open to graduate students in geochemistry, mineralogy, and solid state science; stipend $2,400.

AMERICAN IRON AND STEEL INSTITUTE FELLOWSHIPS (2) — Open to graduate students in geochemistry and metallurgy; stipend $2,400-$4,320.

ARMSTRONG CORK SUMMER FELLOWSHIPS IN CHEMISTRY (5) — Open to graduate students in chemistry.

ATOMIC ENERGY COMMISSION GRADUATE TRAINEESHIPS IN NUCLEAR REACTION OPERATIONS AND UTILIZATION (6) — Open to graduate students in nuclear engineering; stipends comparable to the AEC Special Fellowships.

BROCKWAY GLASS COMPANY FELLOWSHIP — Available to a graduate student in ceramic science whose thesis is in the area of glass science; stipend $3,500-$4,000.

CONTINENTAL OIL COMPANY FELLOWSHIP — Available to a graduate student in petroleum and natural gas engineering for studies in petroleum engineering; stipend $2,280.

CONTINENTAL OIL COMPANY FELLOWSHIP IN PETROLEUM ECONOMICS — Available to a graduate student in mineral economics for studies in petroleum economics; stipend $2,280.

DU PONT FELLOWSHIP — Available to a graduate student in mechanical engineering; stipend $4,200 per year (4 terms) plus tuition. In addition $1,000 fund is available for student research activity.

W. S. ELLIOTT FELLOWSHIP — Available to a graduate student who is a graduate of The Pennsylvania State University and is interested in engineering research; stipend $1,200.

ERNST AND ERNST FELLOWSHIP — Available to a master's candidate in accounting; stipend $1,000

F.I.R.E — Research in field of thermal/mechanical behavior of refractories. Available to a student in ceramic science; stipend $3,000 per year.

HERMAN G. AND SUZANNE G. FISHER FOUNDATION FELLOWSHIP — Available to an advanced graduate student in human development and family studies and especially interested in work with young children; stipend $3,500 for tuition and other expenses.

GENERAL FOODS FUND FELLOWSHIPS (2) — Open to graduate students with a major in the College of Human Development; stipend for doctoral $3,000, for master's $2,000 for tuition and other expenses.

GLASS CONTAINERS INDUSTRIES RESEARCH CORPORATION — Available to graduate students in ceramic science whose thesis is in the area of glass science and technology; stipend $3,000-$3,600.

GULF OIL COMPANY FELLOWSHIP IN PETROLEUM AND NATURAL GAS ENGINEERING — Available to a graduate student for work in petroleum production; stipend $2,400.

HASKINS AND SELLS FOUNDATION FELLOWSHIP — Available to a graduate student in accounting; stipend $2,500.

WALTER E. HELLER FELLOWSHIP — Provided by Walter E. Heller & Company, in the amount of $1,000 for a candidate for the degree of Master of Business Administration.

HILL FELLOWSHIPS FOR STUDY IN ANTHROPOLOGY OR HISTORY — Details available from Dean S. F. Paulson of the College of the Liberal Arts, 108 Sparks Building.

HILL FELLOWSHIPS IN HISTORY — Available to graduate students in history for the completion of the Ph.D. dissertation; nonrenewable; stipend $3,300.

H. R. IMBT SERVICES, INC. FELLOWSHIP — For graduate work in civil engineering in the field of civil engineering construction; stipend $3,000.

INTERNATIONAL LEAD ZINC RESEARCH ORGANIZATION FELLOWSHIP — In support of research on the application of lead and zinc compounds to chemical, ceramic, electrical, and allied industries. Available to two students in ceramic science; stipend $3,000.

INTERNATIONAL LEAD ZINC RESEARCH ORGANIZATION FELLOWSHIP — In support of research on the physics and chemistry of lead and zinc compounds. Available to a student in solid state science; stipend $2,540.

JOSEPH M. JOHNSTON MEMORIAL SCHOLARSHIP — Available to a student whose program is related to floriculture; stipend variable.

SAMUEL H. KRESS FOUNDATION — Makes available travel grants and research stipends for American students in art history, architecture, and conservation; for doctoral candidates only.

NATIONAL ENDOWMENT FOR THE ARTS — Available to all students preparing a thesis. Information available from program chairman; stipend $1,000.

NATIONAL ENDOWMENT FOR THE HUMANITIES FELLOWSHIPS (8) — Available to doctoral candidates upon completion of two full years' participation in the interdisciplinary graduate program in the humanities; stipend $2,400-$3,500. (4) — Available to postdoctoral interns in the interdisciplinary graduate program in the humanities; stipend $8,000. Apply to Director of Program, 118 Sparks Building. Deadline December 31, 1974.

NATIONAL STEEL CORPORATION FELLOWSHIP — Available to a graduate student in metallurgy; stipend $2,880.

NORTON COMPANY FELLOWSHIP — Available to a graduate student in ceramic science for research on thermal/mechanical properties; stipend $3,000.

EDWARD ORTON, JR., CERAMIC FOUNDATION FELLOWSHIPS — For graduate research in ceramic science, especially in regard to the firing behavior of classical ceramic compositions; stipend $4,800 (variable).

OWENS-ILLINOIS FELLOWSHIP — Available to a graduate student in ceramic science whose thesis is in the area of glass science and technology; stipend $3,000-$3,600.

PENNSYLVANIA COOPERATIVE FISHERY UNIT FELLOWSHIPS (3-4) — Open to graduate students in zoology; stipend $2,400-$2,460.

PENNSYLVANIA ENVIRONMENTAL ENGINEERING AND SCIENCE FELLOWSHIPS — Available to graduate students in environmental studies; $5,400 for stipends, plus tuition and related fees.

PENNSYLVANIA MEAT PACKER'S ASSOCIATION SCHOLARSHIP (1) — Open to a selected graduate student specializing in meat science; stipend $600.

PRICE WATERHOUSE FOUNDATION FELLOWSHIP — Available to a Ph.D. candidate in accounting; stipend variable up to $5,000.

PROCTOR AND GAMBLE COMPANY FELLOWSHIP — Available to a U.S. citizen who is a graduate student in chemical engineering; stipend $2,988.

RADIO CORPORATION OF AMERICA FELLOWSHIP — Available to a graduate student in electrical engineering; stipend $2,100-$3,000 for nine months. May be supplemented for an additional three months on application.

REFRACTORIES INSTITUTE FELLOWSHIPS — For graduate research in ceramic science related to refractories; stipend $5,000.

ROCKWELL MANUFACTURING COMPANY FELLOWSHIP — Available to a graduate student in mechanical engineering; stipend $4,200 per year (4 terms) plus tuition. In addition $1,000 fund is available for student research activity.

SEL-REX CORPORATION FELLOWSHIP — Available to a student in ceramic science; stipend $3,000.

SHUBERT FELLOWSHIP IN PLAYWRITING — Available to a student in theatre arts; stipend $2,500.

EDWIN ERLE SPARKS DISSERTATION FELLOWSHIP IN THE HUMANITIES (1) — Available to a doctoral candidate in the humanities (classics: comparative literature, English, French, German; history; philosophy; religious studies; Slavic languages; Spanish, Italian, and Portuguese; speech); stipend $3,500 plus tuition. Apply to relevant department before February 1.

EDWIN ERLE SPARKS FELLOWSHIPS IN THE HUMANITIES (8) — Available to beginning graduate students in the humanities (classics; comparative literature, English, French, German; history; philosophy; religious studies; Slavic languages; Spanish, Italian, and Portuguese; and speech); stipends $2,400 plus tuition. Apply to relevant department before February 1.

SPRAGUE ELECTRIC COMPANY FELLOWSHIP — Awarded through the Materials Research Laboratory; stipend variable up to $3,600.

STACKPOLE FERRITE FELLOWSHIP — Available to a graduate student in ceramic science or solid state science; stipend $3,000.

TEXACO FELLOWSHIP IN ENVIRONMENTAL STUDIES — Available to a graduate student majoring in engineering with environmental emphasis through the Center for Air Environment Studies; stipend $3,000 per year plus tuition.

UNION CARBIDE FELLOWSHIP — Available to a graduate student in mechanical engineering; stipend $4,200 per year (4 terms) plus tuition. In addition $1,000 fund is available for student research activity.

U.S. OFFICE OF EDUCATION FELLOWSHIPS — Open to graduate students with undergraduate degree in engineering, physical science, or mathematics who are preparing as technology teachers in technical institutes and junior colleges; stipend $2,400 for 12 months plus an allowance of $500 for each dependent.

U.S. OFFICE OF EDUCATION TRAINEESHIPS IN EDUCATION OF EXCEPTIONAL CHILDREN (28) — Open to graduate students being prepared as leadership personnel in the education of the mentally retarded, the emotionally disturbed, the learning disabled, and in special education administration; stipend $300-$800 per term plus dependency allowance; $150 per term with no dependency allowance. Apply to the head of the Department of Special Education.

U.S. OFFICE OF EDUCATION FELLOWSHIPS IN SPEECH PATHOLOGY AND AUDIOLOGY: WORK WITH THE SPEECH-HANDICAPPED (5); WORK WITH THE DEAF (4) — Open to graduate students specializing in these fields; stipend up to $2,200-$3,200 plus dependency allowance. Apply to the director of the Speech and Hearing Clinic.

U.S. OFFICE OF EDUCATION PROSPECTIVE TEACHER FELLOWSHIPS IN ENGINEERING TECHNOLOGY (7) — Open to students with baccalaureate degree in engineering, physics, or mathematics who have had two years of experience; stipend $2,400 for 12 months plus dependency allowance of $500 each.

U.S. PUBLIC HEALTH SERVICE AIR POLLUTION SPECIAL FELLOWSHIP (POSTDOCTORAL) — Available to postdoctoral scholars in the physical sciences, biological sciences, and social sciences; stipend $6,000-$7,000 plus dependency allowance.

U.S. PUBLIC HEALTH SERVICE TRAINEESHIPS — Available through Departments of Anthropology, Biological Health, and Biophysics.

U.S. Public Health Service Traineeships in Air Pollution (26) — Open to selected graduate students in the physical sciences, biological sciences, and social sciences; stipend $3,000-$3,600 plus dependency allowance. Applications and information available through the Center for Air Environment Studies.

U.S. Public Health Service Traineeships in Social Gerontology (12) — Open to selected post-master's graduate students in the social and behavioral sciences; stipend $2,600-$2,800 plus dependency allowance. Apply to director, Program in Adult Development and Aging.

U.S. Rehabilitation Services Administration Traineeships in Speech Pathology and Audiology (11) — Open to graduate students specializing in speech pathology and audiology; stipend $2,400-$3,400.

U.S. Rehabilitation Services Administration Traineeships in Therapeutic Recreation (6) — Open to graduate students specializing in therapeutic recreation; stipend $1,800 (three terms).

United States Steel Fellowship — Available to a graduate student in metallurgy; stipend $2,400-$3,600 per year.

U.S. Vocational Rehabilitation Administration Traineeships in Vocational Rehabilitation Counseling (36) — Open to graduate students in counselor education who are specializing in vocational rehabilitation counseling; stipend $1,800-$2,000.

Veterans Administration Internships in Clinical Psychology (5) — Open to selected advanced graduate students in this area of psychology; stipend $3,500-$6,500, not including tuition and fees.

Walter Thomas Memorial Scholarship — Available to a student studying the nutrition of horticultural crops; stipend variable.

Arthur Young and Company Fellowship (1) — Open to a master's degree candidate in accounting from a predominantly black college.

In addition, grants are available from governmental agencies, industrial concerns, foundations, and the armed forces for graduate study, and frequently for support of investigations of particular problems. Some of these permit full-time study and carry the same exemptions as the fellowships listed above. Detailed information may be secured from departments.

EXTERNALLY SPONSORED FELLOWSHIP AND TRAINEESHIP PROGRAMS — Attention is directed to the following national programs, involving numerous fields of study, with which the University cooperates by providing local administration. (See statement of nondiscrimination, page 58.)

Atomic Energy Commission Special Fellowships in Nuclear Science and Engineering — These fellowships are available to United States citizens who hold bachelor's degrees in engineering or physical science (chemistry, earth science, mathematics, or physics) and who have completed mathematics through ordinary differential equations. Applicants for first-year fellowships will be required to take the Graduate Record Examinations, designed to test aptitude and achievement, which are administered in January at a large number of centers in the United States and overseas. Before a fellowship appointment becomes effective, the fellow must be granted fellowship clearance by the Atomic Energy Commission and must be accepted by a participating university for study leading to an advanced degree. The deadline for filing applications for fellowships beginning in September is the first of the preceding January. Forms may be obtained from the NSE Fellowship Office, Oak Ridge Associated Universities, Oak Ridge, Tennessee 37830. About 200 will be awarded.

Federal Highway Administration Fellowships — Provided by the Federal Highway Administration, U.S. Department of Transportation, to develop the expert manpower needed to carry out state and local jurisdiction highway safety programs. Open to engineering graduates for graduate study in highway traffic engineering. Only U.S. citizens are eligible. Fellowships are granted for an academic year at $5,000 each for tuition, books, and living stipends. Application forms are available from the National Highway Institute, 400 Seventh Street, S.W., Washington, D.C. 20590.

Ford Foundation — 320 East 43rd Street, New York, N.Y. 10017 — Offers doctoral fellowships for beginning American Indian, Mexican-American, Puerto Rican, and black students. (Black students should apply through the National Fellowships Fund for Black Americans, 795

Peachtree St. N.E., Suite 484, Atlanta, Ga. 30308.) Each fellowship includes a monthly stipend of $250, tuition, a book and supply allowance, and a dependency allowance. Dissertation-year fellowships for up to $5,000 are also available for research on the history and culture of these ethnic groups, Asian-Americans, and on the role of women in society.

INTERNATIONAL UNIVERSITY FELLOWSHIPS IN SPACE SCIENCE — These graduate and post-doctoral fellowships are available to foreign nationals who hold the equivalent of master of science or master of engineering degrees and meet graduate student entrance requirements at United States universities. Details on the program will be found in the brochure concerning these fellowships issued by the Office of Scientific Personnel, National Academy of Sciences, Washington, D.C. 20418.

NATIONAL DEFENSE MODERN FOREIGN LANGUAGE FELLOWSHIPS — Under Title VI of the National Defense Education Act of 1958, as amended, the U.S. Commissioner of Education allocates to institutions which have approved programs of study in certain languages of critical importance to the United States, and in the cultural areas related to these languages, graduate fellowships for the study of these languages and the related areas. The languages involved in this program are in general those not commonly taught in the United States. French, German, Italian, and Peninsular Spanish are excluded.

Applicants must give reasonable assurance that they will be available after graduate study for teaching a modern foreign language or a related study in a college in the United States or for such other public service as may be specified in the application materials.

In 1972-73 the University awarded four fellowships in Russian language and area studies for majors in Slavic languages, in the Eastern European program for students majoring in Russian, and for those majoring in art history, economics, geography, history, or political science, with emphasis on Eastern Europe but also studying a Slavic language. Write to the head of the department of one of these six graduate programs.

NATIONAL SCIENCE FOUNDATION GRADUATE FELLOWSHIPS — The Graduate School cooperates in this program of prestige fellowships requiring outstanding credentials and available in the biological, engineering, mathematical, and physical sciences; anthropology; economics (excluding business administration); geography, history and philosophy of science; political science; psychology (excluding clinical); and sociology (excluding social work). Also included are interdisciplinary programs such as biophysics, geochemistry, genetics, and physiology. These fellowships are used at the university of one's choice. Application is made during the fall to the Fellowship Office, National Academy of Sciences-National Research Council, 2101 Constitution Ave., N.W., Washington, D.C. 20418, which has charge of evaluating applicants for the Foundation. About 1,000 new awards were made for 1972-73. The stipend is $300/month for three years plus remission of tuition. The application deadline for 1974-75 was November 26, 1973.

OTHER AIDS

GRADUATE SCHOOL TUITION GRANTS-IN-AID — Forty grants of tuition remission for full-time study are awarded each year on a term basis, providing for all tuition. They are available to any graduate degree candidate in his third or a later term at this University on criteria of financial need and academic promise. A recipient is to carry a full program of graduate work but may accept employment with the University or another employer not to exceed ten hours per week, provided he reduces his academic load to 8 or 9 credits. Application for renewal of the grant-in-aid may be made for succeeding terms. The value of these grants to Pennsylvanians is $320 per term, and to non-Pennsylvanians, $720 per term. Applications for grants for the winter, spring, and summer terms must be filed by the fifth week of the preceding term and by mid-April for the fall term. Application forms may be obtained from the Office of Graduate School Fellowships, 317 Kern Graduate Building.

PHI KAPPA PHI GRANTS-IN-AID — One or two tuition grants-in-aid in each of spring and summer terms are available for students completing degree requirements during the term of the award. Application procedures are the same as for Graduate School Tuition Grants-in-Aid.

THE RUTH YOUNG BOUCKE GRADUATE FELLOWSHIP — Established from the estate of Ruth Young Boucke, whose husband was for many years a professor of economics, this fellowship is available every other year to an outstanding graduate student on the same basis as the regular Graduate School fellowships, and selection is made by the Graduate School Committee on Fellowships and Awards. The stipend is up to $2,565 for a tenure of three terms plus a grant-in-aid of tuition.

LUCRETIA V. T. SIMMONS SCHOLARSHIP — The State College Chapter of the American Association of University Women has established a modest scholarship which is awarded annually to honor an outstanding woman graduate student. The award does not include exemption from tuition. Nominations are made by departments. Stipend variable.

LOAN FUNDS — Funds from three sources are available to graduate students. Application forms may be obtained from the Office of Student Aid, Boucke Building.

UNIVERSITY LOAN FUNDS have been established through University organizations, alumni, faculty, staff, and friends. Applicants for long-term loans must demonstrate need for financial assistance in meeting University-related expenses and must be United States citizens. International students are ineligible for long-term loans but may qualify for short-term loans. The interest on long-term loans does not begin until after graduation and is generally at a low rate for the first two years. Upon recommendation of the Graduate School, nondegree students and students who have completed all required credits and are not registered, but are completing their theses and anticipating graduation at the next commencement, may qualify for these loans.

THE ALUMNI GRADUATE FELLOW LOAN FUND has been established through the efforts of the University Alumni Fund. This fund is managed by the Office of Student Aid. The recipients will be selected by the Graduate School as part of its annual fellowship competition by offering a combination of a fellowship plus promise of a loan.

NATIONAL DIRECT STUDENT LOANS are available for United States citizens from the federal government. Evidence of need must be supported by a Confidential Financial Statement. Interest, at 3 percent, does not start until nine months after the borrower ceases to be a full-time student.

STATE HIGHER EDUCATION LOAN PLANS — Some states have passed laws that enable them to set up agencies to guarantee loan agreements with commercial banks, enabling cooperating banks in those states to make long-term personal loans to qualifying students to help pay their college or graduate school expenses. This cooperation makes possible lower interest charges and longer repayment periods than are available for ordinary personal loans.

Pennsylvania has established the Pennsylvania Higher Education Assistance Agency for those who are residents of Pennsylvania and have been accepted for enrollment in an approved institution of higher education. A full-time graduate student may borrow up to $2,500 per year, the total not to exceed $7,500 during the entire period of his post-secondary education. A part-time graduate student is limited to $750.00 per year and, to be eligible, must be enrolled for at least 6 credits. Evidence of need must be supported by a Confidential Statement. A list of participating lending institutions is available from all secondary school counselors, school financial aid officers, or the Pennsylvania Higher Education Assistance Agency, Guaranteed Loan Program, Towne House, Harrisburg, Pa. 17102.

Residents of other states should communicate with their state education departments regarding the existence of similar plans. Practically all the states and the District of Columbia have such programs.

GIRARD EDU-CHECK PLAN — The University offers to sponsors (including parents) of students the Assured Education Plan, enabling them to pay out of current income, on a monthly basis, University bills for tuition, residence hall room and board, and all other items billed by the University. Life insurance and total and permanent disability insurance are a part of the plan for the sponsor up to his sixty-eighth and sixty-first birthdays, respectively. Payments are

handled through the Girard Bank, 2nd and Chestnut Streets, Philadelphia, Pa. 19106. Further information and application forms may be obtained from the Office of the University Bursar, 103 Shields Building. Signed agreements should be received well in advance of registration, since it takes at least three weeks for completion of arrangements.

STUDENT EMPLOYMENT — Many students depend upon part-time employment to help meet their expenses. A student who is thus employed, however, must recognize the time demands of his work schedule and will be required to adjust his academic load accordingly. The Office of Student Aid offers assistance in finding part-time employment in town as well as on campus, and through the Federal College Work-Study program. For participation in the College Work-Study program, evidence of need must be supported by a Confidential Statement.

The State College Area Chamber of Commerce also gives assistance to students concerning part-time employment. The Chamber of Commerce, local placement services, and the University Office of Personnel maintain files of positions open to wives of students. Many local residents seek help for babysitting, housework, typing, and other general kinds of employment.

A student holding a fellowship, traineeship, or scholarship may not accept employment of any kind for service beyond that specified by his appointment. A graduate assistant may accept concurrent employment outside the University only after obtaining permission from the department head or person in charge of his major program. He may not hold a concurrent appointment with the University other than a Fellowship Supplement.

VETERANS' BENEFITS — The Coordinator of Veterans Affairs has the responsibility of handling all applications for benefits under the various public laws.

Under P. L. 89-358, a student is classified as full-time if he registers for 8 or more credits.

After each term's registration, the number of credits scheduled must be reported to the University Coordinator of Veterans Affairs for enrollment certification to the Veterans Administration.

Recently discharged servicemen not in this area may obtain information on veterans' educational benefits under P. L. 89-358 and its recent revision from the Veterans Administration representatives at their local county courthouse.

PROCEDURES AND REGULATIONS

A student is expected to assume full responsibility for knowing the regulations and pertinent procedures of the Graduate School as set forth in the publications, the *Manual for Graduate Students* and the *Thesis Information Bulletin*, and for meeting the standards and requirements expressed by these regulations. The *Manual*, which is available to a student after he has been admitted, sets forth in more detail the procedures governing registration, changes in program, and graduation, and gives other information about the Graduate School which is useful to graduate students. Every student should secure a copy at the Graduate School Information Center soon after admission.

STATEMENT OF NONDISCRIMINATION

In the selection of individuals for graduate study, in which the University has partial or complete control of the selection process and administration of the program, the University will not discriminate on the basis of race, creed, color, sex, or national origin of any applicant.

ADMISSION

An applicant for admission to the Graduate School should understand that graduate work is not a simple extension of an undergraduate program. It operates at a higher level, demands scholarship of a higher order, and emphasizes research, creativity, and professional competence with a minimum of formal requirements and a maximum of student initiative and responsibility.

Objective — The objective of the Graduate School is to admit a graduate student body of high

qualifications up to the limit of the University's resources to provide graduate programs of outstanding quality. In general, a student may begin his graduate work in fall, winter, spring, or summer.

Applicants must recognize that staff, facilities, and other resources are limited so that not all qualified persons can be admitted. The number accepted will vary by program and from term to term. In some graduate programs all vacancies will have been filled long before the deadline for submitting applications so that even outstanding students cannot be accepted.

Application —Students are normally expected to begin work at the University Park Campus unless they have been admitted to an approved graduate program offered at Behrend or King of Prussia Graduate Centers or the Capitol Campus. Applicants interested in programs offered at these locations should apply directly to the appropriate campus. Applicants for the University Park Campus or The Milton S. Hershey Medical Center should apply at University Park. Any exception to this policy must be approved jointly by the graduate department head or program chairman and the Office of Graduate Admissions.

Requirements — For admission to the Graduate School an applicant must have received a baccalaureate degree from an accredited institution, earned under residence and credit conditions substantially equivalent to those required by The Pennsylvania State University. Ordinarily, he must have completed in a satisfactory manner a certain minimum of course work in designated areas, the specific courses and amount of work depending upon the field of advanced work which the student proposes to enter.

A student with a slight deficiency in undergraduate preparation may be admitted and allowed to take a limited number of undergraduate courses to make up the deficiency while proceeding with his graduate program. Courses taken for this purpose do not, of course, apply toward the requirements of the advanced degree.

Admission may be granted to applicants whose credentials are not complete at the time of application because the baccalaureate degree has not yet been conferred, grades for the current term are not yet available, etc. Such admission is subject to cancellation if the complete credentials, on arrival, do not meet the requirements for admission. In the interim, certification of any earned credits will be withheld. If admission should, for any reason, be canceled, the student is thereby automatically dropped from the Graduate School.

Admission is granted jointly by the Graduate School and the department or graduate program in which the student plans to follow his studies. The establishment of standards by which applicants are admitted is a departmental or program responsibility. Though the Graduate School has no fixed minimum grade-point requirement for admission, an applicant is generally expected to maintain during his junior and senior years quality in his work equivalent to a grade-point average of at least 2.50 on The Pennsylvania State University grading scale of A (4) to D (1). Individual programs may establish higher grade-point averages and other criteria by which they will judge candidates for admission. Departments or major programs may also, in exceptional cases, approve admission by reason of special backgrounds, abilities, and interests. Departmental or program requirements are given in the descriptive statements appearing under the major programs listed in the latter part of this publication.

The above requirements apply particularly to the student who recently completed an undergraduate program and is about to begin graduate study. An applicant who has obtained a graduate degree at a recognized graduate school will be evaluated largely on the basis of the graduate record.

A student who has been admitted to a program in which the doctorate is offered may begin working toward that degree, but he has no official status as a doctoral student and no assurance that he will be accepted as a doctoral candidate until he has passed a candidacy examination administered by his major department or committee.

Forms — Forms to be used in applying for admission can be obtained from the Office of Graduate Admissions. Applicants may apply for admission to only one program at a time. All academic records, and explanation of the grading system used, should be submitted, *in duplicate*, to the Office of Graduate Admissions, 310 Kern Graduate Building. These must be received from all institutions by the Graduate School at least one month prior to the opening of the term in which the student plans to begin his graduate program.

Deadlines — The deadline for processing of applications by the Graduate School is one month

prior to the beginning of a specific term. GRADUATE MAJOR PROGRAMS MAY REQUIRE EARLIER DEADLINES. A complete Graduate School admissions file, which is required for processing an application, includes the following items: (1) application blanks, (2) application fee form, (3) a check or money order in the amount of $15.00 made payable to The Pennsylvania State University, and (4) duplicate transcripts from each institution of higher education attended. This applies to the complete academic record, both undergraduate and graduate. Supplementary materials and examination scores may be required in individual programs. If the admission file is incomplete a month prior to the beginning of the term for which the student has applied, his materials will be processed for the first term following the completion of his admissions file.

Nondegree — A student who plans to take courses for transfer to another institution or to follow a program of study not leading to an advanced degree at this instituion should apply for admission as a nondegree student. The adviser for such a student may be appointed by the department head or program chairman most closely associated with the student's field of interest. The number of nondegree students which can be admitted is limited because preference is given to students in degree programs.

Foreign Students — Foreign students should plan on applying at least six months prior to the beginning of the term. They must submit certified English translations of all academic records. Since many programs require the TOEFL score for admission, this score should be submitted with the application. Foreign students are not admitted as nondegree students unless such admission is requested by a sponsoring agency.

UNDERGRADUATE STUDENTS — A senior student of The Pennsylvania State University lacking not more than 4 credits for graduation may be admitted to the Graduate School. This limit may be increased to 8 credits in the case of a student with an average of at least B (a grade-point average of 3.00). Any senior with a 3.50 grade-point average may be admitted to 500-level courses with the consent of the instructor; other undergraduate students with a B average or better may be admitted to such courses with the consent of the instructor and the Dean of the Graduate School.

In certain cases undergraduate students may subsequently apply credits they have earned in 400- and 500-series courses toward an advanced degree at The Pennsylvania State University. Upon admission to the Graduate School those credits *relevant* to the graduate program of study which were not used to satisfy undergraduate requirements will be entered on the student's graduate transcript. These may then be applied toward an advanced degree provided they are acceptable to the major program and minor field. The time limitation on the completion of a master's degree program applies to these as well as to other credits.

GUESTS OF THE UNIVERSITY — It is the policy of this Graduate School not to permit applicants to work for a second doctoral degree. The President, on recommendation of the Dean of the Graduate School, will welcome as guests holders of earned doctoral degrees who may be visiting the University Park Campus for purposes of noncredit study. Guest privileges apply to persons holding the degree from The Pennsylvania State University or other accredited colleges and universities. Guests may attend seminars and courses and, if space and facilities are available, carry on research. There will be no charge except for laboratory expenses. Arrangements should be made in advance with the Dean of the Graduate School.

STUDENT PENNSYLVANIA RESIDENT STATUS — Whenever it appears that an applicant for admission is not domiciled in Pennsylvania, it is assumed that the applicant is a non-Pennsylvanian. If a student who is thus admitted believes that the circumstances do not justify his/her classification as a non-Pennsylvanian, he/she may file a written petition with the Financial Officer for the Dean of the Graduate School, 316 Kern Graduate Building, University Park, Pa. 16802, for reclassification. Capitol Campus students may petition the Capitol Campus Financial Officer.

A copy of the *Policy for Determination of Students' Pennsylvania Resident Status Approved by the Auditor General of Pennsylvania*, dated March 29, 1973, can be obtained in the Office of the Financial Officer mentioned above. Under the rules of this document, when a written

petition for reclassification is made, the petitioner is required to present proof of bona fide domicile within the Commonwealth or such other evidence as is pertinent to a complete review of his classification. Upon review, a decision by the highest designated authority at the University shall constitute an exhaustion of administrative remedies. If the student is not satisfied with the decision, a written appeal to the Office of the Auditor General, 229 Finance Building, Harrisburg, Pa. 17120, may be made. This decision on the challenge shall be final.

Any reclassification resulting from a student's challenge shall be effective for tuition purposes as of the date such challenge was filed. A student who changes his/her domicile from Pennsylvania to another state must promptly give written notice to the University.

CLASSIFICATION OF STUDENTS

A graduate student may be admitted either as a degree student or as a nondegree student, depending upon his objectives. After admission to one of these categories, any change to the other must be arranged through the Office of Graduate Student Programs.

DEGREE STUDENTS — A degree student is one who plans to become a candidate for an advanced degree at The Pennsylvania State University and who has been formally admitted for advanced studies in a particular program. The program of study is developed under the guidance of an adviser appointed by the head of the student's major program. A degree student who has passed a candidacy evaluation is classified as a doctoral candidate.

NONDEGREE STUDENTS — An applicant who meets all requirements for admission to the Graduate School, but who does not wish to work for an advanced degree at this institution, may arrange for a program of work as a nondegree student. This classification includes any who plan to transfer credits to another institution and those who plan special programs of study not leading to an advanced degree. The number of nondegree students who can be admitted is limited, and it is increasingly difficult to provide for them because of the limitation of total enrollment. Preference is given to students in degree programs.

Nondegree students who are applying for admission to the University Park Campus *must* submit two transcripts from each institution attended. Transcripts should be sent to the Office of Graduate Admissions, 310 Kern Graduate Building, The Pennsylvania State University, University Park, Pa. 16802.

The admission of a nondegree graduate student at the University Park Campus will be subject to the recommendation of the program chairman or head of the department in which he proposes to do most of his work or in which his major interest lies. Casual students with broad interests, not easily identifiable with a single program, may be admitted directly by the Graduate School. Applications and credentials must be received at least one month prior to the anticipated term of enrollment.

ADJUNCT STUDENTS — An adjunct student is not a graduate student, inasmuch as he has not earned a baccalaureate degree, and may not register for graduate courses or research (500 and 600 series) without permission of the Dean of the Graduate School. An adjunct student may register for 400-level courses provided he has attained at least junior standing in college. He is admitted through undergraduate admissions.

Credits earned as an adjunct student may not ordinarily be applied subsequently toward an advanced degree.

PROGRAMS

MAJOR PROGRAM — A student's major program is his field of primary interest and the one in which the greater portion of his work is taken. Programs are designed to prepare the student to assume a position of informed and responsible authority in his field and to contribute creatively to it. They promote not only specialization, but also breadth of scholarship, the ability to study and think independently, and familiarity with the principal techniques and important

literature in the field. The research undertaken by the candidate should deal with a problem which represents a significant contribution to knowledge.

INTERDISCIPLINARY MAJORS — In addition to the graduate major programs listed in this bulletin, interdisciplinary majors involving two or more departments within a single College or intercollege majors involving two or more Colleges may be arranged with the approval of the Dean of the Graduate School. These programs are offered under the supervision of appropriate interdepartmental or intercollege committees.

In general, departments of the University are identified with specific major programs. Thus, aerospace engineering is a major program of study which is offered under the supervision of the Department of Aerospace Engineering. On the other hand, engineering acoustics and genetics are major programs for which there are no corresponding departments. In such cases, a committee of the Graduate School is responsible for administering the program. In some cases a single department offers work in more than one program. For instance, the Department of Material Sciences offers work in ceramic science, fuel science, metallurgy, and mineral processing.

Applicants for admission are encouraged to consult the person whose name is listed under the major program heading.

MINORITY STUDENTS — Different Colleges and departments offer graduate study relating to minority students, and financial assistance is sometimes available. Information may be obtained from the deans of the Colleges or through the graduate programs of the students' major interests.

ADVANCED DEGREES OFFERED

The degrees of Doctor of Philosophy and Doctor of Education are conferred by the University. Both require high attainment and productive scholarship, but the Ph.D. places a strong emphasis on research, whereas the D.Ed. emphasizes professional competence in some field of education or teaching.

The Master of Arts and the Master of Science degrees are academic in nature, the programs placing strong emphasis on basic knowledge and research. The professional master's degrees conferred are the Master of Administration, Master of Agriculture, Master of Business Administration, Master of Education, Master of Engineering, Master of Environmental Pollution Control, Master of Fine Arts, Master of Forestry, Master of Nursing, Master of Psychosocial Science, Master of Public Administration, and Master of Regional Planning.

A candidate for the M.Adm., M.Eng., M.P.A., or M.Ps.Sc. degree may meet all the requirements for his degree at a Graduate Center or the Capitol Campus of The Pennsylvania State University provided the major program head or supervising committee and the Dean of the Graduate School have agreed that a complete program of study leading to the specific degree can be pursued at these locations. Thus a complete program leading to the degree of Master of Engineering with a major in engineering science has been approved for the Behrend Graduate Center, the King of Prussia Graduate Center, and the Capitol Campus. Such designation of location of the completion of the program will be noted on the student's transcript.

CHANGE OF DEGREE OR PROGRAM

A graduate student who has been admitted for work in one major program, but wishes to transfer to another, should submit his request to the Office of Graduate Student Programs of the Graduate School. The student's credentials will be reviewed and the proposed new major department head or committee chairman consulted. If the change is approved, the student may be required to make up certain undergraduate deficiencies if he is inadequately prepared for the new major.

A graduate student admitted for either an academic degree (M.A., M.S., or Ph.D.) or a professional degree (M.Adm., M.Agr., M.B.A., M.E.P.C., M.Ed., M.Eng., M.F., M.F.A., M.N., M.P.A., M.Ps.Sc., M.R.P., or D.Ed.) who wishes to change to another type of degree program must apply to the Office of Graduate Student Programs of the Graduate School for the transfer.

Similarly, a student who has earned a master's degree must apply for a formal transfer if he plans to work for a doctor's degree of a different type. A student may be required to make up certain deficiencies if inadequately prepared for the new program.

GRADUATE CREDITS

It is important that the student understand that in the Graduate School the word "credit" has no meaning other than as a unit of time — time spent in residence and in off-campus graduate work. One credit stands for the equivalent of approximately one week of full-time graduate work, and 10 credits for a term's work.

Typically, a candidate for an advanced degree is required to earn a certain minimum number of credits at The Pennsylvania State University. Consequently, there is a limit to the number of credits he may earn at another approved institution or through continuing education to meet the minimum requirements of his degree. Moreover, the department or committee in charge of a major program may require a student to do more of his work at the University than specified by the limitations set by the Graduate Faculty.

CONTINUING EDUCATION — A large number of courses carrying credit are given throughout the Commonwealth of Pennsylvania by Continuing Education. All 400-series courses so offered may carry graduate credit for students who have been admitted to the Graduate School. The graduate adviser's signature is required on the official registration form, which the student submits at the designated place of registration for the course.

There is no limit to the number of graduate credits which a student may earn in Continuing Education, but not more than 10 graduate credits so earned may be applied toward the minimum requirements for an advanced degree.

REGISTRATION

The responsibility for being properly registered rests with the student. At least until his program is near completion, he is expected to register for each term in which he proposes to do either course work or research toward his thesis, whether it be on or off campus. In the case of research, the number of credits shall be determined by the amount of time required for the investigation, one credit representing the equivalent of one week of full-time work. In the later stages of his program the situation will determine the requirements for the student's registration.

ADVISERS — To assist the student in planning his program, the head of his major department or program chairman will designate a member of the faculty to serve as adviser. It is the student's responsibility to secure the name of his adviser from the department head and to seek a conference before registration.

TIME OF REGISTRATION — Registration days are indicated in the calendar at the beginning of this bulletin.

A student is expected to complete his registration during the officially designated period and to attend the first meeting of all classes in which he is enrolling. If this is impossible because of some emergency or unusual circumstance beyond his control, the student may be granted permission by his instructor to miss a few class meetings, it being understood that work missed will be made up subsequently. Under these conditions the Dean of the Graduate School may grant the student permission to register late. In general, a student who receives permission to register late will be required to reduce his program in proportion to the length of time he has been absent.

Regardless of when he may begin attending classes, a student who fails to complete the process of registration within the officially designated registration period will be liable for the late registration charge.

CONTINUITY OF REGISTRATION — A student who registers at University Park without interruption for each of the three terms in the September-to-June interval, for all four terms each

year, or for each summer term is considered to have maintained a normal continuity of registration.

Anyone who has interrupted such a normal sequence and now plans to register for work at the University Park Campus is required to apply to the Dean of the Graduate School at least one month before the time of registration for permission to resume study.

The policy may be summarized for any specific term as follows:

Summer Term — Application required unless the student was registered at University Park for the preceding spring term or the preceding summer term.

Fall Term — Application required unless the student was registered at University Park for the preceding summer term or the preceding spring term.

Winter Term — Application required unless the student was registered at University Park for the preceding fall term.

Spring Term — Application required unless the student was registered at University Park for the preceding winter term.

PROCEDURE — For each registration the student, in consultation with his adviser, prepares a schedule of courses and research designed to fit his individual needs. The credit load will be reviewed by the Dean of the Graduate School at the time of registration. The registration process is completed in the manner specified for all students at the University.

Under certain conditions credit may be earned by work done away from the campus. A student contemplating such work should inquire of the Dean of the Graduate School about the procedures and conditions. The student must assume responsibility for the registration process, but the operation can be handled by mail. Registration must be completed before the close of central registration at University Park.

A student must register for courses audited as well as for those taken for credit.

REGISTRATION NEAR THE COMPLETION OF A PROGRAM — A candidate for the Ph.D. degree who is following the new regulations, which went into effect in the fall term 1967, is required to register continuously (at least three terms per calendar year) from the time he has both passed the comprehensive examination and met the three-term, full-time academic requirement until his thesis is accepted by his doctoral committee, regardless of whether he is working on his thesis during this interval.

Other doctoral candidates and master's students may be required to register for a normal credit load because of their appointment status. If not, and if they have earned more than 90 or 30 credits, respectively, and have met the requirements for their degrees except for the completion of the thesis, these students may register for as few as two credits per term. A student who has met the minimum requirements for his degree and is now completing his research and thesis writing off campus is not required to register, even if he comes to the campus several times each term to see his adviser.

A student, other than one following the new Ph.D. requirement, is not required to register for his final term in order to graduate or in order to make minor revision to his thesis and/or to take a final examination for his degree.

VISITING AND AUDITING CLASSES — A graduate student who wishes to attend classes without receiving credit may secure permission either to visit or to audit courses during a term for which he has registered.

As a visitor, a student may attend classes with the approval of the instructor but may not claim the usual privileges of class membership such as participating in discussion, doing practicum work, or taking examinations. He does not register for the privilege of visiting, nor does any record appear on his transcript.

As an auditor, a student may participate in class discussion, do practicum work, take examinations, and generally share the privileges of a class member. The student registers in the same manner as if he were taking the course for credit and pays the same fees. He receives no credit and cannot subsequently secure credit for work done in the course; however, the Records Office shows on the grade report and the record the actual number of credits assigned to the course. Thus, when a student receives an audit grade, the number of credits which he audited is shown.

A student who, because of his status as a graduate assistant or fellow, is required to register for a certain minimum number of credits, is not permitted to count those courses for which he is registering as an auditor for this purpose. The 1G and 2G language courses are an exception. Beyond the required minimum he may register for credit or audit but may not exceed the normal maximum without special permission.

In general, students are encouraged to visit classes rather than to register for a course as auditors. However, visiting is not permitted in German 1G and 2G.

In the 1G and 2G courses offered by the language departments, no distinction is made between registering for credit and for audit in considering loads.

RESEARCH AND THESIS WORK — In registering for thesis work a student uses the appropriate number (600, 601, 610, or 611) preceded by the abbreviation designating his major field. Thus Engl. 600 denotes thesis research in English being done on the University Park Campus and Engl. 610, thesis research in English being done off campus.

The numbers 601 and 611 are used for special registration for thesis preparation work. They are available *only* to Ph.D. candidates who are following the new regulations, have passed the comprehensive examination, and have met the three-term, full-time academic requirement. Such a candidate in engineering mechanics will register for E.Mch. 601 if he is engaged full time in the preparation of his thesis or for E.Mch. 611 if he is engaged only part time in the preparation of his thesis.

It should be assumed that 600 and 610 are available to all graduate major programs and that 601 and 611 are available in all programs approved for the Ph.D., although these numbers may not always appear in the *Schedule of Classes* for each term.

COMMON COURSES — The following courses for which students may register have been set up for common use by major programs, with Senate approval, to encourage innovation and provide flexibility in designing graduate programs:

590. COLLOQUIUM (1-3) Continuing seminars which consist of a series of individual lectures by faculty, students, or outside speakers.

596. INDIVIDUAL STUDIES (1-6) Creative projects, including nonthesis research, which are supervised on an individual basis and which fall outside the scope of formal courses.

597. SPECIAL TOPICS (1-6) Formal courses given on a topical or special interest subject which may be offered infrequently; several different topics may be taught in one year or term. A specific title may be used in each instance and will be entered on the student's transcript. Multiple offerings may be accommodated by the use of suffixes (a), (b), etc.

LOADS, ACADEMIC AND EMPLOYMENT — To provide flexibility in arranging loads for graduate assistants and full-time University staff members, a procedure has been set up whereby the normal credit limits may be changed by permission of the person to whom the student or staff member is responsible for his service assignment or University employment. Responsibility for the consequences of a graduate student's changing his course load rests with the student and his adviser. The course load is a factor in determining whether a graduate student is classified as a full-time or part-time student; has established residency requirements; and is eligible to hold a fellowship, scholarship, assistantship, or departmental or program appointment.

The University takes the position that the facilities of the Graduate School should be made available only to students who can profit from their graduate school experience to the maximum extent. More than doing what is required in courses or in research, the graduate experience is one of living in a scholarly atmosphere and seriously engaging in scholarly pursuits. It means profiting from hearing visiting scholars and artists and from engaging in discussions, both formal and informal, with faculty members and fellow students. It is an involvement and participation in student affairs, University and Graduate School governance, committee assignments, and personal contribution of effort to the welfare and betterment of the University graduate community. It should mean leisure time for reflection and for exploring fields related to, although not directly a part of, one's specialty. Students who propose schedules of few credits not requiring serious effort, or those who wish to carry overloads of such proportion as to

handicap them seriously in achieving maximum quality find it difficult and often impossible to experience the satisfaction of a well-rounded scholarly attainment.

Thus, a graduate student should strive for a balance between his academic load, employment, or appointment which will classify him as a full-time graduate student with all the privileges and responsibilities intrinsic to this classification, and he should be so certified by his department head or program chairman.

FULL-TIME ACADEMIC LOADS — In establishing credit loads, a student is classified as full-time in any term for which he is registered for 8 to 10 credits, *or* holds a quarter-time assistantship and schedules 7 to 9 credits, *or* has a half-time graduate assistantship and schedules 5 to 7 credits. A three-quarter-time assistant may schedule 4 to 5 credits and is classified as a *part-time* student.

PART-TIME ACADEMIC LOADS — A student is classified as part-time in any term for which he is registered for less than 8 credits unless he holds a half-time or quarter-time assistantship.

STAFF EMPLOYEE CREDIT LOADS — A full-time staff employee of the University may schedule 4 credits (up to 16 credits per academic year) per term, either for credit or audit.

No member of the faculty in one of the professorial ranks in the University may receive from the University the master's degree or the doctoral degree.

For University staff employees desiring to take graduate degree work, admission to the Graduate School is a first essential.

EMPLOYMENT — Many students depend upon part-time employment to help meet their expenses. A student who is thus employed, whether on campus or off campus, must recognize the time demands of his work schedule in planning his academic program. A student holding a fellowship or scholarship may not accept employment of any kind for service beyond that specified by his appointment. Graduate assistants may accept concurrent employment outside the University only after obtaining permission from the head of the department providing the assistantship or from the person in charge of his graduate program. A graduate assistant may not hold a concurrent appointment with the University other than a Fellowship Supplement.

COURSE-NUMBERING SYSTEM — Courses in the series 1-399 are not listed in this bulletin because they are strictly undergraduate and yield no graduate credit. A graduate student may register for or audit these courses in order to make up deficiencies or fill in gaps in his earlier education but not to meet requirements for an advanced degree.

Courses in the series 400-499 are for upperclassmen with at least junior standing and for graduate students. Only a limited number of credits earned in these courses may be counted toward the requirements for an advanced degree. Detailed regulations concerning the restrictions are given on pages 75-80 under the specific requirements for the various master's degrees.

Courses in the series 500-599 are restricted to students registered in the Graduate School, seniors with an average of at least 3.50, and other students who have been granted permission to enroll by the Dean of the Graduate School.

The numbers 600 (on campus) and 610 (off campus) are available for credit in thesis research in all graduate major programs. The numbers 601 and 611 do not denote courses but are used for noncredit special registration for thesis preparation by a Ph.D. candidate who is following the new regulations which went into effect in fall term 1967. Registration under these numbers will maintain his status as a student during the interval which begins at the time he has both passed the comprehensive examination and met the three-term, full-time academic requirement and ends at the time his doctoral committee accepts the thesis. The student will register for 601 if he is engaged full time in the preparation of his thesis; he will register for 611 if he is engaged only part time in the preparation of his thesis. Candidates for the Ph.D. degree do not receive grades for noncredit registrations (601 and 611).

SCHEDULE OF COURSES — A complete list of the courses which will be offered in any specific term is given in the *Schedule of Classes,* which is available at nominal cost from the Scheduling Office approximately four months before the beginning of the term. It gives the number of credits being offered in each course, the hours at which the class will meet, the location of the class, and in some cases the instructor's name.

GRADING SYSTEM

A grade is given solely on the basis of the instructor's judgment as to the student's scholarly attainment.

The following revised grading system is now in effect: Any one of five quality grades (A, B, C, D, F) may be given a graduate student for course work or for thesis research. The grade-point equivalents are 4, 3, 2, 1, 0, respectively.

At the 400, 500, and 600 levels grades of A, B, and C denote graduate credit, whereas D and F are failing grades for graduate students, D being the normal failing grade. A grade of F indicates doubt in the judgment of the instructor of the student's potential for further graduate study.

A minimum grade-point average of 3.00 for work done at the University is required for graduation in the case of all candidates whose first registration for graduate study at the University occurred in the spring term 1964 or later.

In addition to the quality grades listed above, two symbols, "Def." (deferred) and "R," may appear on a student's transcript. If work is incomplete at the end of a term for a reason beyond the student's control, or if very little work remains to be done, the instructor may report "Def." in place of a grade, which will appear temporarily on the student's record.

In the case of thesis work, either in progress or completed, and certain courses approved by the University Senate, the instructor may report the symbol "R" in place of a grade. This symbol indicates that the student has devoted an adequate amount of time to the work scheduled but gives no indication of its quality. When reported for thesis work, this symbol will not influence the grade-point average and remains on the student's transcript permanently if not converted to a quality grade (A, B, C, D, or F) within one term of its recording. Quality grades reported for a given term for thesis work will be included in the cumulative grade-point average. Quality grades reported for research will not apply to R's given for earlier registrations and will not denote the quality of an entire series of R's.

UNSATISFACTORY SCHOLARSHIP

A graduate student who fails to maintain satisfactory scholarship or to make acceptable progress in his degree program will be dropped from the University. Action may be initiated by the department or committee in charge of the graduate major or by the chairman of the student's doctoral committee.

GRADUATION

It is the responsibility of the student to inform the Graduate Recorder of his intention to graduate (by filing a diploma card) and to pay the thesis fee at the beginning of the term in which he expects to receive an advanced degree. If he does not graduate that term, he must reactivate the diploma card by indicating to the Graduate Recorder the term in which he intends to graduate. Deadlines are given in the calendar found at the beginning of this bulletin.

See the *Manual for Graduate Students* for a detailed statement of procedure concerning graduation. Attendance at commencement exercises is expected, but forms for permission to receive the degree in absentia are available in the Office of Graduate Student Programs in 211 Kern Graduate Building and in the Office of Graduate Records in 112 Shields Building.

All degrees conferred are tentative until final grade reports have been received and all requirements fulfilled, even though the student's name may have appeared in the commencement program.

DOCTORAL DEGREES

The Doctor of Philosophy, an academic degree, and the Doctor of Education, a professional degree, are conferred by the University. Recognized as different in purpose, the two programs consequently have different requirements in certain respects.

ADMISSION

A student who has been admitted to the Graduate School and has been accepted by the department or committee in charge of a major program in which the doctorate is offered may begin working toward a doctoral degree. However, he has no official status as a doctoral student and no assurance that he will be accepted as a doctoral candidate until he has passed a candidacy examination. This examination is administered by the major department or graduate program and is given early in the student's program.

GENERAL REQUIREMENTS

No specified number of courses completed or credits earned will assure attainment of the doctorate. The general requirements are based upon a period of residence, the writing of a satisfactory thesis, and the passing of a comprehensive and a final oral examination. A doctoral program consists of such a combination of courses, seminars, and individual study and research as meets the minimum requirements of the Graduate School and is approved by the doctoral committee for each individual student.

A master's degree is not a prerequisite for the doctorate in some major programs. However, the first year of graduate study leading to the Ph.D. may be substantially the same as that provided for the M.A. or M.S. degree. Similarly the first year of the D.Ed. program may be essentially the same as that provided for the M.Ed.

GRADE-POINT AVERAGE

A minimum grade-point average of 3.00 for work done at the University is required for admission to the comprehensive examination and for graduation in the case of all candidates whose first registration for graduate study at the University occurred in the spring term 1964 or later.

TIME LIMITATION

A student is required to complete his program within seven years from the date of his acceptance as a candidate.

OFF-CAMPUS AND TRANSFER CREDITS

Subject to the approval of his adviser and the head of his major department or program chairman, a student may register for research to be done away from the University Park Campus.

A maximum of 30 credits beyond the baccalaureate at an approved school not granting the doctorate in the student's major program may be accepted by the Graduate School in partial fulfillment of the requirements for a doctoral degree at The Pennsylvania State University. A maximum of two full academic years of work (60 credits) beyond the baccalaureate at a graduate school which grants the doctorate in the candidate's major program may be accepted here to apply toward doctoral degree requirements. Advanced standing is awarded for only one master's degree. Academic work to be so transferred must meet the following criteria: (1) It must have been completed within five years prior to the date of admission to the Graduate School of The Pennsylvania State University, (2) it must appear on a graduate transcript, (3) it must be of at least "B" quality, and (4) it must be deemed applicable to the student's program by his current academic adviser, approved in writing, and submitted to the Graduate School Director of Admissions.

The following caveat should be noted. Pass-fail grades are not transferable to an advanced degree program unless the "pass" can be substantiated by the former institution as having at least "B" quality.

A completed master's degree may be transferred to a doctoral program with no intervening time limitation.

ADVISERS AND DOCTORAL COMMITTEES

After a student has been admitted to a degree program, he should confer with the head of his major department or program concerning procedures and the appointment of an adviser. Arrangement and approval of the details of the student's term-by-term schedule is the function of the adviser. This person may be a member of the doctoral committee or someone else designated by the head of the major program for this specific duty.

General guidance of a doctoral candidate is the responsibility of a doctoral committee consisting of four or more members of the Graduate Faculty. One member shall be from outside the candidate's major program. This committee is appointed by the Dean of the Graduate School, upon recommendation of the head of the major program, after the student is admitted to candidacy. At his discretion, the Dean may add other members to the committee. The supervisor of the candidate's thesis will usually, but not necessarily, be designated as chairman. The chairman must hold senior membership in the Graduate Faculty. An associate member may supervise the research for a doctoral candidate, and, with the approval of the Dean of the Graduate School, he may serve as chairman of a doctoral committee and thus may sign the title page of a thesis.

The doctoral committee is responsible for establishing the broad outline of the student's program and should review the program as soon as possible after his admission to candidacy. It will prepare, give, and evaluate the candidate's examinations, and supervise and approve his thesis. A favorable vote of at least two-thirds of the members of the committee is required for passing a comprehensive or a final oral examination. If a candidate fails an examination, it is the responsibility of the doctoral committee to determine whether he may take another examination.

The committee will also notify the Dean when the candidate is ready to have his comprehensive and his final oral examination scheduled and will report the results of these examinations to the Dean.

COMMUNICATION AND FOREIGN LANGUAGE COMPETENCE

A candidate for the degree of Doctor of Philosophy is required to demonstrate high-level competence in the use of the English language, including reading, writing, listening, and speaking. Proficiency is expected at the time of admission to the Graduate School or must be achieved before admission to candidacy.

In addition to demonstrating competence in English, each candidate for the Ph.D. must meet any communication and foreign language requirements which have been established by his major program.

If a candidate is to be examined for a reading knowledge of a foreign language other than French or Spanish, he must report his intention to take the examination to the secretary of the language department by the end of the first week of classes for the term during which he wishes to take it. This date is one week prior to the examination date. The examination will be administered on dates announced in the Graduate Calendar at the beginning of this bulletin.

The Pennsylvania State University has been named as a testing center for the administration of the written tests for students to be examined in French or Spanish. These test dates can be found in the Graduate Calendar in the front of this publication. Students must make application to take these tests at least two weeks prior to the examination dates by contacting the administrator of these tests, Professor A. V. Kozak, 166 Chambers Building, University Park, Pa. 16802.

Candidates for the Doctor of Education degree may be required to demonstrate competency in foreign languages.

CANDIDACY EXAMINATION

This examination is administered by the Graduate Faculty in the major graduate program and should be taken early in the student's program. The nature of the examination varies with the program and may be the master's examination if so allowed. The decision to admit a student to candidacy or to reject him must be made by Graduate Faculty or a designated committee of Graduate Faculty. For the Ph.D. student following the new requirements, the examination may be given after he has earned at least 12 credits in graduate courses beyond the baccalaureate. He must take the examination not later than three terms in which he has registered after earning 24 credits.

For all other Ph.D. and D.Ed. students, the examination should be given when the student has earned a total of approximately 30 credits, including his master's program and work done elsewhere. A student transferring from another graduate school with 30 or more transfer credits must be given the candidacy examination before he has earned more than 10 credits here.

COMPREHENSIVE EXAMINATION

When a candidate for the Ph.D. or D.Ed. degree has substantially completed his course work, he is required to take a comprehensive examination covering his major program and minor field of study.

A candidate for the Ph.D. must have satisfied the communication and foreign language requirement before taking the examination.

All candidates whose first registration for graduate study at the University occurred in the spring term 1964 or later are required to have a minimum grade-point average of 3.00 for work done at the University at the time the comprehensive examination is given.

The examination is officially scheduled and announced by the Dean of the Graduate School upon recommendation of the doctoral committee. It is given and evaluated by the doctoral committee and may be *either written or oral, or both.* A favorable vote of at least two-thirds of the members of the committee is required for passing. In case of failure it is the responsibility of the doctoral committee to determine whether the candidate may take another examination. The results are reported to the Dean of the Graduate School and will be entered on the candidate's official record.

When a period of more than five years has elapsed between the passing of the comprehensive examination and the completion of his program, the student is required to pass a second comprehensive examination before the final oral examination will be scheduled.

FINAL ORAL EXAMINATION

The doctoral candidate who has satisfied all other requirements for the degree will be scheduled by the Dean of the Graduate School, on recommendation of the doctoral committee, to take a final examination. Normally the final oral examination may not be scheduled until at least three months have elapsed after the comprehensive examination was passed, although the Graduate Dean may grant a waiver in the case of an outstanding student. The deadline for holding the examination is seven weeks before commencement.

The final examination is oral, open to the public, and related in large part to the thesis; but it may cover the candidate's whole program of study without regard to courses that have been taken either here or elsewhere.

A favorable vote of at least two-thirds of the members of the committee is required for passing. The results of the examination are reported to the Dean of the Graduate School and will be entered upon the candidate's official record. If a candidate fails, it is the responsibility of the doctoral committee to determine whether he may take another examination.

Ph.D. — ADDITIONAL SPECIFIC REQUIREMENTS

The degree of Doctor of Philosophy is conferred in recognition of high attainment and productive scholarship in some special field of learning as evidenced by (1) the satisfactory completion of a prescribed period of study and investigation, (2) the preparation of a thesis involving independent research, and (3) the successful passing of examinations covering both the special subject and the general field of learning of which this subject forms a part.

In the fall term 1967 a revised set of requirements for the Ph.D. went into effect. A student who, by the end of the summer term 1967, had earned 45 or fewer graduate credits which were applicable toward his degree follows the new requirements.

RESIDENCE REQUIREMENTS

There is no required minimum of credits or terms of study, but over some twelve-month period during the interval between admission to candidacy and completion of the Ph.D. program the candidate must spend at least three terms (which may include the term in which the candidacy examination is taken) as a registered student, during which time he is engaged in full-time academic work on the University Park Campus or at The Milton S. Hershey Medical Center *and* is certified by his department as devoting half time or more to graduate studies and/or thesis research to meet his degree requirements.

After a student has passed the comprehensive examination and met the three-term residence requirement, no further registration for credit will be required by the Graduate School. He shall, however, maintain his status as a student by registering continuously (at least three terms per calendar year) until the thesis is accepted by his doctoral committee. This registration may be for (1) noncredit 601 or 611 only, for which he pays the special thesis preparation fee, (2) noncredit 601 or 611 for which he pays the special thesis preparation fee plus course registration at the regular per credit fee, and (3) full-time course credits for which he pays the regular tuition fee. Grades are not given for noncredit 601 or 611.

OLD RESIDENCE REQUIREMENTS

A student who had earned more than 45 credits by the end of the summer term 1967 will be required to span a minimum of nine terms in full-time graduate study and research (10 credits per term), or their equivalent in credits (90 credits), for the Ph.D. At least 30 credits must be earned in residence at the University Park Campus.

For a period of three terms, two of which must be consecutive, the Ph.D. candidate must limit his work load to half-time at most, the balance of his time being devoted to graduate study.

A graduate assistant or research assistant who is a candidate for the doctorate, has passed the comprehensive examination, is registered for the maximum allowable credit load, and is certified by his department as devoting all his time to studies and thesis research to meet his degree requirements may be regarded by the Dean of the Graduate School as a full-time student for a period not exceeding one calendar year. Such a student will be considered to earn the equivalent of 10 credits per term, and three such terms will meet the minimum residence requirement for the Ph.D.

MINOR FIELD

A Ph.D. candidate is not required by the Graduate Faculty to have a minor field of study. However, a department or a committee in charge of a major field may require a candidate to offer work in a minor field, or a student may elect such a program with the permission of his doctoral committee.

A minor consists of no fewer than 15 credits, including those applied toward the master's degree, of integrated or articulated work in one field related to, but different from, that of the major. A minor program must meet the approval of the departments or committees responsible for both the major program and the minor field.

THESIS

The ability to do independent research and competence in scholarly exposition must be demonstrated by the preparation of a thesis on some topic related to the major subject. It should represent a significant contribution to knowledge, be presented in a scholarly manner, reveal an ability on the part of the candidate to do independent research of high quality, and indicate considerable experience in using a variety of research techniques. The contents and conclusions of the thesis must be defended at the time of the final oral examination.

The completed thesis, together with two copies of an abstract, must be filed in the Office of Theses and Publications not later than five weeks prior to the commencement at which the candidate expects to receive the degree.

A *Thesis Information Bulletin*, which gives details concerning format, paper, illustrations, and other items, may be obtained at the Graduate School Office of Theses and Publications, 320 Kern Graduate Building.

D.Ed. — ADDITIONAL SPECIFIC REQUIREMENTS

Programs leading to the degree of Doctor of Education are not limited to specific fields of education but, with the consent of the department or committee in charge and concurrence by the dean of the College, may also be offered in any other field appropriate to the preparation of teachers which has been approved for the doctorate.

The degree is conferred in recognition of advanced preparation of a high order for work in the profession of education as evidenced by (1) satisfactory completion of a prescribed period of study; (2) ability to apply scientific principles in classroom instruction, supervision of instruction, administration, or as a consulting specialist in certain educational areas; (3) preparation of a thesis demonstrating ability to undertake an educational problem with originality and independent thought; and (4) successfully passing examinations, i.e., showing a satisfactory grasp of the field of specialization and its relation to allied educational areas.

RESIDENCE REQUIREMENTS

A minimum of nine terms of full-time graduate study and research (10 credits per term), or their equivalent in credits (90 credits), of which at least 30 credits must be earned in residence, is required for the D.Ed. degree. The D.Ed. candidate may meet the requirements by attending summer terms unless his major department requires a period of registration in other terms or in consecutive terms at University Park. A candidate may register for a maximum of 30 credits of research in absentia, but none of these may count toward the minimum of 30 credits which he is required to earn on the University Park Campus. It is expected that students will register for a minimum of 15 credits of thesis research. The maximum credit load permitted a student who is employed full time is 4 credits per term.

MAJOR PROGRAM AND MINOR FIELD

The program of study includes a major and either a minor or a group of general studies. A majority of the courses offered in fulfillment of the requirements must be in the major program of study.

A candidate choosing a major outside the field of education (such as speech, geography, or history) shall have a minor consisting of no fewer than 15 credits in education, including those applied toward the master's degree, as approved early in his program by a faculty adviser designated by the College of Education.

A candidate choosing a major in one of the major programs in education must also choose either a minor or a group of general studies with the approval of the major program chairman. In this case a minor consists of no fewer than 15 credits, including those applied toward the master's degree, in one field outside those of education. An acceptable general studies group consists of no fewer than 15 credits, including those applied toward the master's degree, in fields

outside those of education considered by the major program committee to have significance and value for the candidate.

COMPREHENSIVE EXAMINATION

In addition to demonstrating a high level of competence in the subject matter of his major program and minor field, each candidate must show in his comprehensive examination that he is familiar with current theories of education; that he understands and can apply the techniques and the findings of educational research so far as they bear upon the teaching of his subject; that he is prepared to read understandingly and contribute to the technical and professional literature in his field; and that he can criticize his own procedures in the light of historical trends and practices in this and other countries. Command of the tools for a thorough study of the problems of education is necessary and must include familiarity with statistical methods. For certain students the requirements may include a reading knowledge of one or more foreign languages.

All candidates whose first registration for graduate study at the University occurred in the spring term 1964 or later are required to have a minimum grade-point average of 3.00, for work done at the University, at the time the comprehensive examination is given.

THESIS

Evidence of a high degree of scholarship, competence in scholarly exposition, and ability to select, organize, and apply knowledge must be presented by the candidate in the form of a written thesis. The candidate must demonstrate a capacity for independent thought as well as ability and originality in the application of educational principles or in the development of new generalizations under scientific controls. A thesis may be based upon a product or project of a professional nature, provided scholarly research is involved. For example, it may be based upon the solution of a professional problem concerned with the development of a curriculum, or a product of creative effort related to education. However, in order to be acceptable as a thesis, the professional project must be accompanied by a written discourse demonstrating the nature of the research and including such theories, experiments, and other rational processes as were used in effecting the final result. The topic and outline of the proposed thesis must have the approval of the doctoral committee.

The completed thesis, together with two copies of an abstract, must be filed in the Office of Theses and Publications not later than five weeks prior to the commencement at which the candidate expects to receive the degree.

A *Thesis Information Bulletin*, which gives details concerning format, paper, typing, and other requirements, may be obtained at the Graduate School Office of Theses and Publications, 320 Kern Graduate Building.

MASTER'S DEGREES

The Graduate School recognizes a difference in purpose, which is reflected in the requirements, for two types of advanced degrees, academic and professional. Of the fourteen master's degrees conferred, the Master of Arts and Master of Science are academic in nature. The professional degrees conferred are Master of Administration, Master of Agriculture, Master of Business Administration, Master of Education, Master of Engineering, Master of Environmental Pollution Control, Master of Fine Arts, Master of Forestry, Master of Nursing, Master of Psychosocial Science, Master of Public Administration, and Master of Regional Planning.

A degree is not conferred for a mere collection of credits. A well-balanced, unified, and complete program of study will be required, which may frequently exceed the minimum requirements specified below.

A student may meet the degree requirements by either full-time or part-time enrollment and by attendance in any combination of terms. The student who interrupts the continuity of his registration faces the possibility of not being granted permission to return.

GRADE-POINT AVERAGE

A minimum grade-point average of 3.00 for work done at the University is required for graduation in the case of all candidates whose first registration for graduate study at the University occurred in the spring term 1964 or later.

TIME LIMITATION

All requirements for a master's degree, whether satisfied on the University Park Campus or elsewhere, must be met within six years or a period spanning seven consecutive summers.

ADMISSION

In addition to the general University requirements for admission set forth at the beginning of this bulletin, adequate undergraduate preparation is required in the program in which the applicant expects to pursue advanced work. The specific courses and the total number of undergraduate credits required in various areas will be determined by the choice of program and can be ascertained from the descriptive statement appearing under the major program heading in the latter portion of this bulletin. An applicant who meets the necessary grade-point average but is deficient in course preparation may, under certain circumstances, be admitted to the Graduate School and allowed to make up the undergraduate deficiencies. Under these circumstances the program will require more than the necessary period of residence. An applicant for admission to the M.Ed. program in most major programs is required to have had at least 18 credits in education and related psychology, and in certain major programs may be required to have had practice teaching.

After a student has been admitted to a degree program, he should confer with the head of his major department or program concerning the appointment of an adviser. The general guidance of a master's candidate is the responsibility of an adviser, or of a committee appointed in a manner to be determined by the major department or program in which the student is specializing. The adviser or the committee assists the student in planning a program of study. Although the adviser is frequently the supervisor of the thesis, this is not necessarily the case.

Requirements concerning courses, language proficiency, minors, comprehensive examinations, and other matters are sometimes made by departments or programs in addition to (but not in conflict with) the regulations of the Graduate School. For details the student should consult the head of the major department or program.

TRANSFER CREDIT

Subject to the limitations given below on the use of credits earned at other accredited institutions, a maximum of 10 credits of high quality graduate work done at another institution may be applied toward a master's degree here.

The student should distinguish carefully between the transferability of credit and its applicability in a particular degree program as approved in writing to the Graduate School Director of Admissions by his academic adviser. Such academic work transferred must have been completed within five years prior to the date of admission to the Graduate School of The Pennsylvania State University, must be of at least "B" quality, and must appear on a graduate transcript.

Pass-fail grades are not transferable to an advanced degree program unless the "pass" can be substantiated by the former institution as having at least "B" quality.

Forms for transfer of credit may be obtained from the Office of Graduate Admissions, 310 Kern Graduate Building.

EXAMINATIONS

A candidate may be required to pass in a satisfactory manner such written or oral examinations as his program head may designate. A candidate should consult his major department for such special requirements.

Examinations to establish credit for work done *in absentia* or without formal class work may be used to remove undergraduate deficiencies, but *not* to earn credits toward an advanced degree. Arrangements are made by the student directly with his major department or program.

Graduate Record Examinations are designed to test information and abilities in basic fields of knowledge. Provisions are made on the campus for administering these examinations at scheduled times and upon request of students or department program chairmen. Informational materials may be obtained at the Graduate School Information Center.

ENGLISH PROFICIENCY OF FOREIGN STUDENTS

Entering graduate students from countries other than the United States are required to demonstrate high-level competence in the use of the English language, including reading, writing, speaking, and listening. Upon arrival at the University, such students are requested to report to the Office of International Student Affairs, 111 Kern Graduate Building, where an appointment for the English language proficiency interview will be made. Students with an obviously good command of English will be exempted from formal testing; others will be scheduled for a series of proficiency tests. The Graduate School at The Pennsylvania State University requires all foreign graduate students who are working toward a degree to meet the established English language proficiency requirement. Remedial work will be prescribed as indicated by the tests.

Before a foreign student can be accepted for enrollment at The Milton S. Hershey Medical Center and in many graduate major programs, a high-level competence in the use of the English language must be demonstrated by successful performance on the TOEFL (Test of English as a Foreign Language). Information on the time and place that this test is given in his geographical area can be obtained by writing to the Educational Testing Service, Box 592, Princeton, N. J. 08540.

M.A. and M.S. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Arts and the Master of Science degrees have similar requirements, the general major area determining which degree is conferred. Programs for both degrees are strongly oriented toward research.

A minimum of 30 graduate credits is required, of which at least 20 must be earned at an established graduate campus of the University. A minor is not required of all candidates for the M.A. or M.S. degree. A department or committee in charge of a major program may require a candidate to offer work in a minor field, or a student may elect such a program with the permission of his committee.

A minor consists of no fewer than 6 credits of integrated or articulated work in one field related to, but different from, that of the major. A minor program must meet the approval of the departments or committees responsible for both the major program and minor field.

The major department or the committee in charge of the major program is the judge as to the suitability of a field for the minor and of its relevance to the major. The minor field department has the responsibility of accepting or rejecting students, advising on courses to be taken by the candidate in the field, examining the candidate in the area of studies he has undertaken in the field, and certifying that the minor requirements have or have not been met.

At least 18 credits in the 500 and 600 series combined must be included in the program. A minimum of 12 credits in course work (400 and 500 series), as contrasted with research, must be completed in the major program. A thesis is required of many candidates for these degrees. Details are given in the introductory paragraphs under the major program headings in the latter part of this bulletin. If a student is required to write a thesis, at least 6 credits in thesis research (600 or 610) must be included in his program. If no thesis is required, at least 18 credits must be in 500 courses.

Those candidates who are not required to write a thesis must present a suitable essay or paper. Its nature and extent shall be determined by the major program. The department head or program chairman shall report to the Dean of the Graduate School the title, the name of the faculty member under whom the student did the work, and whether the work was considered

adequate. The program head may require one or more copies of such an essay for its library or other files.

A thesis is prepared under the direction of the department or program in which the candidate's major work is taken. Under certain conditions a student may complete the thesis off campus. To do so he must make satisfactory arrangements in advance with his adviser and the head of his major department or program.

Requirements for the M.A. degree at the Capitol Campus differ somewhat from the above and are outlined under the major programs in American studies and humanities. These programs are available only at the Capitol Campus.

A *Thesis Information Bulletin*, which gives details concerning format, paper, typing, and other requirements, may be obtained at the Graduate School Office of Theses and Publications, 320 Kern Graduate Building.

M.Adm. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Administration degree program is intended to meet the professional needs of practicing and potential administrators in the fields of business and engineering. All students must satisfy preparatory requirements for their particular program and complete at least 30 credits of graduate courses, with the majority of the courses at the 500 level. Two options are offered: (1) the business administration option is intended for students who desire to pursue an administrative career in business, industry, or institutions, and (2) the engineering administration option prepares individuals for management positions in engineering, scientific, and technical organizations. Each student is required to complete a professional paper of the quality, if not the theoretical depth, of a thesis, and it must be defended before a committee of Graduate Faculty members. The candidate will be expected to demonstrate his ability to integrate knowledge of a specialized area with a broad understanding of the general field of administration.

The program is offered only at the Capitol Campus.

M.Agr. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Agriculture is a professional degree. Thus, programs leading to this degree provide opportunities for students to increase their knowledge and competences in the various phases of agriculture. A student, according to his needs, may obtain (1) intensive training encompassing a wide spectrum of subject matter area or (2) intensive training in a specialized area. The emphasis of the program is to enable students to develop skill as professional practitioners in the communication of technical knowledge and its application to the solution of current and future technical, economic, and social problems of individuals and groups.

The head of the department or program chairman shall appoint a three-member committee to guide and monitor the candidate's professional development. Members of this committee must represent at least two departments. The chairman of the appointed committee shall serve as the candidate's adviser. Early in his program, the candidate will inform the committee of his background and aspirations. The committee will suggest to the student how best to achieve these goals and the standard of professional competence required for the Master of Agriculture degree.

A minimum of 30 graduate credits is required of which 20 credits must be earned in residence at the University Park Campus. A maximum of 10 credits may be earned in special problem-type courses.

The candidate must present an acceptable paper on a selected professional problem or a report of internship training. Up to 3 graduate credits will be given for an acceptable paper. The candidate may be required to provide one or more copies of the paper for the University.

The candidate's committee shall report through the department head or program chairman to the Dean of the Graduate School the title of the paper and whether the paper and the candidate's academic performance were considered satisfactory.

M.B.A. — ADDITIONAL SPECIFIC REQUIREMENTS

The purpose of the Master of Business Administration degree program is to develop professional managerial knowledge and skills as these are applied to the decisions in business enterprises. Teaching focuses upon the techniques, the theory, and the skills important to modern administrators.

At least 36 graduate credits are required, of which 18 or more are to be completed at the 500 level and 26 hours at University Park. Candidates who are admitted without an undergraduate business background may be required to undertake up to 30 hours of work preparatory to full status as an M.B.A. candidate. During the later stages of course work, some specializations within a major area of student interest and an M.B.A. project paper are undertaken. Applications must include the results of the Admission Test for Graduate Study in Business sent directly from the Educational Testing Service.

M.Ed. — ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Education provide preparation for increased professional competence in the areas of education and teaching. They should be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Arts or Master of Science. In most major programs the requirements for admission include 18 credits in education and related psychology.

A minimum of 30 graduate credits is required for the degree, of which at least 20 must be earned at an established graduate campus of the University; at least 24 must be in course work. This degree is offered also at the Capitol Campus and the King of Prussia Graduate Center.

MAJOR PROGRAMS IN THE FIELDS OF EDUCATION

A student may major in one of the approved programs in education, such as art education, educational psychology, or home economics education, and proceed under the guidance of the appropriate major in education.

A program of this type requires at least 6 credits to be earned outside the programs in education.

MAJOR PROGRAMS OUTSIDE THE FIELDS OF EDUCATION

A student who is preparing to teach in a specific subject-matter field, such as geography, mathematics, or German, may choose such a program as his major and take the majority of his work in it under the guidance of the department offering that major. A student wishing to work in a broader area may choose a major such as biological science, earth sciences, physical science, or social studies and take at least 24 credits in the area under the guidance of the committee in charge of the major.

Each candidate is required to earn 6 credits in education as directed by the faculty of one of the approved graduate programs in education. The 6 credits may be taken in educational foundations, which includes courses in comparative education; history, sociology, and philosophy of education; and educational psychology.

THESIS OR PAPER

Six credits may be granted for an approved thesis. A candidate who does not elect to write a thesis is required to present an essay or paper. It must be of considerable proportion, indicating capacity to describe a serious intellectual experience adequately in writing, and giving unmistakable evidence of ability to formulate and state meaningfully the purpose of an investigation, study, critical analysis, or evaluation; to acquire and analyze information; to draw conclusions logically; and to relate findings to professional problems and practices. The nature and extent of such a piece of writing, whether it be required in connection with a course or independently

of course work, and when it is to be undertaken shall be determined by the major program. The department head or program chairman shall report to the Dean of the Graduate School the title, the name of the faculty member under whom the student did the work, and whether the work was considered adequate. It is the right, but not the responsibility, of the department head or program chairman to require one or more copies of such an essay for its library or other files.

M.Eng. — ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Engineering provide training for advanced professional competence in the several fields of engineering. They should be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Science.

A minimum of 30 graduate credits is required, of which 20 must be earned at an established graduate campus of the University. At least 12 credits must be earned in graduate courses (500 series).

A scholarly written report on a developmental study involving at least one area represented in the candidate's course work is required as an integral part of the program. The report must be comparable in its level of work and quality to a graduate thesis. The topic of the developmental study is subject to prior approval by the department in which the candidate's major work is taken, and preparation of the written report shall be under the direction of that department.

No work for this degree is required to be done specifically on the University Park Campus provided the major department or supervisory committee and the Dean of the Graduate School agree that a complete program of study can be pursued at the Capitol Campus or at the Behrend or King of Prussia Graduate Centers of The Pennsylvania State University.

M.E.P.C. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Environmental Pollution Control is an intercollege professional degree designed for students who are interested in pursuing a career in the field of environmental pollution control. Special requirements include 9 credits of core courses covering air and water pollution control and solid waste management and participation in the environmental pollution control seminar program. A minimum of 30 graduate credits are required, of which at least 9 must be at the 500 level and 20 must be taken at the University Park Campus. A thesis will be optional. If a thesis is written, at least 6 credits of thesis research (600 or 610) must be taken.

M.F. — ADDITIONAL SPECIFIC REQUIREMENTS

The program leading to the degree of Master of Forestry provides training for increased professional competence in the several specialized areas of forest resource management and forest products. It should be distinguished carefully from the research-oriented program which leads to the academic degree of Master of Science with a major in forest resources.

A minimum of 30 graduate credits is required, of which at least 20 must be earned on the University Park Campus.

A candidate for the degree of Master of Forestry should choose one area for his major and one or two related areas for his minor. The proportion of credits to be taken in the major and minor fields of study will be determined in consultation with the student's advisory committee. It is expected that the larger part of the program shall be in graduate courses (500 series), but no specific number of credits in the 500 series is required.

Each candidate is required to submit an acceptable thesis based on at least 6 credits of thesis research.

M.F.A. — ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Fine Arts provide training for increased professional competence in the several specialized areas of the arts. They should be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Arts with a major in art, music, or theatre arts.

A minimum of 48 credits is required, of which at least 38 must be earned on the University Park Campus. The larger part of these credits should be above the 400 level, but the needs of the student shall be considered in arranging the best combination of courses and research for the preparation of the candidate in his particular field.

A professional project, either creative or interpretative, is required. This project shall include a monograph in support of the creative or interpretative aspect; such monograph shall represent a minimum of 6 credits on the 600 level.

M.N. — ADDITIONAL SPECIFIC REQUIREMENTS

The purpose of the Master of Nursing degree program is to develop specialized skills in nursing. The program focuses on safety, efficiency, patient assessment (physical and psychosocial), and patient welfare and satisfaction. Besides the scientific principles guiding nursing practice, students examine the moral, ethical, and legal aspects of health care, with freedom to explore creative solutions to management problems.

A minimum of 30 credits is required, with at least 20 to be earned as approved residence credits. At least 10 of these credits must be earned in nursing practicum courses. Other off-campus sites may be used for selected practicums. Each student must present an acceptable clinical paper and pass a comprehensive examination.

M.P.A. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Public Administration is a professional degree for students who are planning careers in public administration in local, state, and national governmental jurisdictions or in international, private, or voluntary agencies. This program should be distinguished from the research-oriented program which leads to the academic degree of Master of Arts with a major in political science in which the candidate may specialize in public administration.

For the M.P.A. degree a minimum of 30 graduate credits is required, of which 20 must be earned at an established graduate campus of the University. The greater portion of the courses must be at the 500 level. An M.P.A. essay or paper will also be required but will carry no graduate credit. A comprehensive final examination will be given to all candidates.

The M.P.A. degree offered at the Capitol Campus at Middletown requires a minimum of 30 graduate credits including a professional master's paper. There is no comprehensive final examination, but an oral defense of the master's paper is required.

The degree is a terminal one, and credits earned in the program may or may not be applicable, even in part, toward a doctorate.

M.Ps.Sc. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Psychosocial Science degree, Community Psychology Option, is a non-traditional program with an emphasis on practicum experience. The program is concerned with equipping students with some of the skills necessary to cope effectively with the multi-faceted problems facing communities. Students should be able to recognize problems, to outline and implement possible solutions to these problems, and to evaluate the effectiveness of the solutions.

Thirty-three graduate credits are required, 21 at the 500 level. A major portion of this degree is field work under the supervision of a faculty member. A paper is a necessary part of the practicum experience. An oral defense of the paper is required.

M.R.P. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Regional Planning is a professional degree for students interested in a coordinated attack on the problems of community development and resource management. The program is intended to acquaint the student with rational programs of spatial allocation of land uses and facilities, maintenance of cultural and aesthetic values, and legal and governmental techniques for their implementation.

A minimum of 45 graduate credits is required, of which 35 must be earned at an established graduate campus of the University. A minimum of 36 credits is required in planning courses, at least 6 of which will be earned in preparing (1) a problem-oriented thesis, or (2) an individual project report, comparable in quality and scope to a graduate thesis, or (3) a project written in a terminal integrative course in regional planning.

GRADUATE MAJOR PROGRAMS OF STUDY

The following degrees are the ones normally conferred in each of the designated major programs. Additional professional degrees, including the M.Agr., M.Ed., and M.Eng., have been authorized in many cases and may be offered at the discretion of the department head or program chairman and the Dean of the Graduate School. For example, the M.Ed. has been authorized for all of the above programs in which a master's degree is conferred provided the program is appropriate to the preparation of teachers.

Academic Curriculum and Instruction — Ph.D., D.Ed., M.S., M.Ed.
Administration (Capitol) — M.Adm.
Aerospace Engineering — Ph.D., M.S.
Agricultural Economics — Ph.D., M.S., M.Agr.
Agricultural Education — Ph.D., D.Ed., M.S., M.Ed.
Agricultural Engineering — Ph.D., M.S.
Agronomy — Ph.D., M.S., M.Agr.
American Studies (Capitol) — M.A.
Anatomy (Hershey) — Ph.D., M.S.
Animal Industry — Ph.D., M.S., M.Agr.
Animal Nutrition — Ph.D., M.S.
Anthropology — Ph.D., M.A.
Architectural Engineering — M.S.
Architecture — M.S.
Art — M.A., M.F.A.
Art Education — Ph.D., D.Ed., M.S., M.Ed.
Art History — Ph.D., M.A.
Astronomy — Ph.D., M.S.
Biochemistry — Ph.D., M.S.
Bioengineering — Ph.D., M.S.
Biological Chemistry (Hershey) — Ph.D., M.S.
Biological Science — D.Ed., M.Ed.
Biology — Ph.D., M.S.
Biophysics — Ph.D., M.S.
Botany — Ph.D., M.S.
Business Administration — Ph.D., M.S., M.B.A.
Ceramic Science — Ph.D., M.S.
Chemical Engineering — Ph.D., M.S., M.Eng.
Chemistry — Ph.D., M.S.
Civil Engineering — Ph.D., M.S., M.Eng.
Classics — M.A.
Community Systems Planning and Development — Ph.D., M.S.
Comparative Literature — Ph.D., M.A.
Computer Science — Ph.D., M.S.
Counselor Education — Ph.D., D.Ed., M.S., M.Ed.
Dairy Science — Ph.D., M.S.
Developmental and Remedial Reading — M.Ed.
Earth Sciences — D.Ed., M.Ed.
*Ecology — Ph.D., M.S.
Economics — Ph.D., M.A., M.Ed.
Education of Exceptional Children — Ph.D., D.Ed., M.S., M.Ed.
Educational Administration — Ph.D., D.Ed., M.S., M.Ed.
Educational Psychology — Ph.D., M.S.
Electrical Engineering — Ph.D., M.S.
Elementary Education (Capitol) — M.Ed.
*Engineering Acoustics — Ph.D., M.S., M.Eng.
Engineering Mechanics — Ph.D., M.S., M.Eng.
Engineering Science (Behrend, King of Prussia, Capitol) — M.Eng.
English — Ph.D., D.Ed., M.A., M.Ed.
Entomology — Ph.D., M.S., M.Agr.
*Environmental Pollution Control — M.S., M.Eng., M.E.P.C.
Extension Education — M.Agr., M.Ed.
Food Science — Ph.D., M.S.
Forest Resources — Ph.D., M.S., M.F.
French — Ph.D., M.A.
Fuel Science — Ph.D., M.S.
General Engineering — M.Ed., M.Eng.
*Genetics — Ph.D., M.S.
Geochemistry — Ph.D., M.S.
Geography — Ph.D., D.Ed., M.S., M.Ed.
Geology — Ph.D., M.S.
Geophysics — Ph.D., M.S.
German — Ph.D., M.A., M.Ed.
Higher Education — D.Ed., M.Ed.
History — Ph.D., D.Ed., M.A., M.Ed.
Home Economics Education — Ph.D., D.Ed., M.S., M.Ed.
Horticulture — Ph.D., M.S., M.Agr.
Human Development and Family Studies — Ph.D., D.Ed., M.S., M.Ed.
Humanities (Capitol) — M.A.
Industrial Engineering — Ph.D., M.S., M.Eng. (King of Prussia, M.Eng.)
Journalism — M.A.
Laboratory Animal Medicine (Hershey) — M.S.
Linguistics — Ph.D., M.A.

*Intercollege Graduate Programs

Man-Environment Relations — Ph.D., D.Ed., M.S., M.Ed.
Mathematics — Ph.D., D.Ed., M.A., M.Ed.
Mathematics (King of Prussia) — M.Ed.
Mechanical Engineering — Ph.D., M.S., M.Eng.
Metallurgy — Ph.D., M.S.
Meteorology — Ph.D., M.S.
Microbiology — Ph.D., M.S.
Microbiology (Hershey) — Ph.D., M.S.
Mineral Economics — Ph.D., M.S.
Mineral Engineering Management — M.Eng.
Mineral Processing — Ph.D., M.S.
Mineralogy and Petrology — Ph.D., M.S.
Mining Engineering — Ph.D., M.S., M.Eng.
Music — M.A., M.F.A.
Music Education — D.Ed., M.Ed.
Nuclear Engineering — Ph.D., M.S., M.Eng.
Nursing — M.N., M.S.
Nutrition — Ph.D., D.Ed., M.S., M.Ed.
Nutrition in Public Health — M.S.
+Operations Research — Ph.D., M.S.
Petroleum and Natural Gas Engineering — Ph.D., M.S.
Pharmacology (Hershey) — Ph.D., M.S.
Philosophy — Ph.D., D.Ed., M.A., M.Ed.
Physical Education — Ph.D., D.Ed., M.S., M.Ed.
Physical Science — D.Ed., M.Ed.
Physics — Ph.D., D.Ed., M.S., M.Ed.
*Physiology (U.P., Hershey) — Ph.D., M.S.
Plant Pathology — Ph.D., M.S.
Political Science — Ph.D., M.A.
Poultry Science — Ph.D., M.S.
Psychology — Ph.D., M.S.
Psychosocial Science (Capitol) — M.Ps.Sc.
Public Administration — M.P.A.
Public Administration (Capitol) — M.P.A.
Recreation and Parks — M.S., M.Ed.
*Regional Planning — M.R.P.
Religious Studies — Ph.D., M.A.
Rural Sociology — Ph.D., M.S., M.Agr.
Sanitary Engineering — M.S., M.Eng.
*School Psychology — D.Ed., M.S., M.Ed.
Slavic Languages and Literatures — M.A.
Social Studies — M.Ed.
Sociology — Ph.D., M.A.
*Solid State Science — Ph.D., M.S.
Spanish — Ph.D., D.Ed., M.A., M.Ed.
Speech Communication — Ph.D., D.Ed., M.A.
Speech Pathology and Audiology — Ph.D., D.Ed., M.S., M.Ed.
Statistics — Ph.D., M.S., M.A.
Theatre Arts — M.A., M.F.A.
Veterinary Science — Ph.D., M.S.
Vocational Industrial Education — Ph.D., D.Ed., M.S., M.Ed.
Wildlife Management — M.S.
Zoology — Ph.D., M.S.

+Dual-title Program Option

GRADUATE MAJOR PROGRAMS AND COURSES*

ACADEMIC CURRICULUM AND INSTRUCTION (AC&I)

PAUL W. BIXBY, *In Charge of Graduate Programs in Academic Curriculum and Instruction*
168 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Bixby, Bliesmer, Brewer, Cartwright, Dupuis, Dwyer, Fagan, Fowler, Golub, Greenhill, Heilman, Heimer, McAulay, Searles, Trueblood, Welliver, Withall, and Zafforoni.

Graduate Faculty: Associate Members Alfke, Alessandro, Askov, Bell, Branca, Chipley, Fairchild, Johnson, Koble, Kozak, Miller, Sharp, Shemick, Short, Shrigley, Singh, and Szabo.

This program provides advanced professional preparation in the special areas of curriculum and supervision, elementary and early childhood education, industrial arts education, language education, mathematics education, science education, and social studies education. Candidates for the Ph.D. and D.Ed. degrees must meet all requirements, including residence, described in the earlier sections of this bulletin.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign languages.

Candidates for the D.Ed. degree with a minor in curriculum and instruction must take a minimum of 15 course credits approved in advance by the person in charge of one of the special areas of the Division of Academic Curriculum and Instruction. Candidates for the M.Ed. degree with a minor in curriculum and instruction must take a minimum of 6 course credits approved in advance.

For admission to the D.Ed. degree program, teaching experience and at least 18 credits in education are required. Students with a 2.75 junior-senior average and with appropriate course and professional backgrounds will be considered for admission, subject to the limitation of program facilities.

CURRICULUM AND SUPERVISION (C & S)

400. INTRODUCTION TO RESEARCH LITERATURE (3)
401. MEASUREMENT AND EVALUATION OF INSTRUCTION, K-12 (3)
402. PROFESSIONAL TERM IN ELEMENTARY EDUCATION (12)
403. PRACTICUM IN STUDENT TEACHING (10)
404. PROFESSIONAL ORIENTATION OF THE ELEMENTARY TEACHER (3)
470. WORKSHOP IN SELECTED STUDIES IN CURRICULUM (1-6)
471. WORKSHOP IN SELECTED STUDIES IN SUPERVISION (1-6)
472. ADVANCED THEORY OF KINDERGARTEN (3)
473. SECONDARY EDUCATION IN AMERICA (3)
490. (Human. 490) HUMANITIES FOR TEACHERS (3)

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*A course abbreviation, a number, and a title designate each course. Course designations and official abbreviations are listed in the left-hand margin just above the first course in each group. The figures in parentheses following the course title show the number of credits which may be granted for that course. In the case of courses with variable credits, the number of credits which may be earned in a single term is determined by the department or program offering the course.

A department or major program may schedule an entire section of a course below the 400 level for fewer credits than the maximum authorized. In 400- and 500-series courses an individual student may schedule fewer credits than the minimum number but in no case more than the maximum number authorized.

All courses listed under graduate major programs may not be required in the particular major.

570. Problems Seminar for Experienced Educators (3) Historical, psychological, social, and economic factors influencing educational programs. Prerequisite: 12 credits in education and psychology.

571. Seminar in Contemporary Issues in Elementary Education (1-3) Conferences and discussions designed to meet the needs of experienced teachers and principals in the field of elementary education. Prerequisites: 6 credits in elementary education and teaching experience.

572. Issues and Trends in Early Childhood Education (3) Research, experimental programs and emerging trends in early childhood education; relationships between educational experiences and later intellectual and emotional development. Prerequisites: C.&S. 472, Ed.Psy. 400.

573. Organization of the Elementary School Curriculum (3) Principles underlying curriculum construction. Primarily for elementary education majors. Prerequisite: C.&S. 402 or teaching experience.

575. Organization of the Secondary School Curriculum (3) Functions of laymen, pupils, teachers, supervisors, and administrators in secondary school curriculum construction. Prerequisites: 12 credits in education and psychology, and teaching experience.

576. Curriculum Theory K-12 (3) The analysis and use of the foundations which underlie models of curriculum design. Prerequisite: C.&S. 573 or 575.

577. Seminar in Curriculum Research (3) Seminar designed to meet the need for special study of particular research projects in elementary and secondary education. Prerequisite: 12 credits of graduate work in education.

579. Workshop in Curriculum and Supervision (1-6) For experienced teachers and supervisors involved in changing educational programs.

580. Supervision of Student Teachers (3) A course in supervision for master teachers, department heads, and college teachers with supervisory responsibilities in teacher education. Prerequisites: teaching experience and 18 credits in education including at least 5 in methods.

581. Principles of Instructional Supervision (3) Social and institutional settings for instructional supervision; functions, activities, and practices of supervision; supervisory case studies.

582. Systematic Observation of Instruction (3) Construction and use of valid and reliable systematic observation systems used as a basis for classroom observation of instruction. Prerequisite: student teaching or teaching experience.

583. Internship in Curriculum and Supervision (3-6) Internship in schools or educational facilities where student is not employed, under supervision of graduate faculty in student's major area.

588. Problems, Projects, and Area Studies in Curriculum and Instruction (1-6) Independent work in the study of topics in curriculum and instruction; development of new curricula, materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of program chairman.

INDUSTRIAL ARTS EDUCATION (IA ED)

460. Planning and Management of Instructional Resources (3)
461. Technology in the Elementary School (3)
462. Independent Study in Industrial Studies (2)
463. Selected Topics in Industrial Studies (1-6)
464. Curriculum and Instruction: Industrial Studies (3)
465. Preprofessional Experience in Industrial Studies (1-3)

561. History and Philosophy of Industrial Arts (2-3) Historical developments and concurrent educational philosophies of industrial arts in American education.

562. Curriculum Development in Industrial Arts Education (2-3) Analysis of curriculum innovations in industrial arts and cognate fields; strategies for implementing curricular

change; construct and assess curriculum materials. Prerequisite or concurrent: I.A.Ed. 561. Prerequisite: teaching experience.

563. Supervision and Administration of Industrial Arts Education (2-3) How to organize, supervise, and administer functioning programs of industrial arts; duties of a supervisor and director of industrial arts. Prerequisite or concurrent: I.A.Ed. 562. Prerequisite: teaching experience.

564. Evaluation in Industrial Arts (2-3) Construction of informal manipulative and written tests; use of standardized mechanical aptitude tests; construction and use of performance rating scales. Prerequisite: C.&S. 400 or 401.

568. Research in Industrial Arts (2-3) Research techniques in industrial arts education. Prerequisite or concurrent: C.&S. 400.

569. Seminar in Industrial Arts (1-9) Directed intensive study, investigation or research in selected phases of the program; reports and constructive criticism. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

INSTRUCTIONAL MEDIA (INSTM)

411. Orientation to Instructional Media (2)
412. Production and Utilization of Graphic Stimulus Materials (3)
413. Production of Educational Motion Pictures (3)
414. Television in Education (3)
415. Systematic Instructional Development (3)

511. Organization and Administration of Media in Schools (3) Problems of providing instructional media in schools; the role of the media consultant in curriculum construction. Prerequisite: Inst.M. 411.

LANGUAGE EDUCATION (L ED)

400. Teaching Reading in the Elementary School (3)
401. Methods of Teaching Language Arts in Elementary School (3)
440. The Elementary School Reading Program (3)
441. Teaching Children's Literature (3)
442. The Elementary School Language Arts Program (3)
443. Teaching English in the Secondary Schools (4)
444. Seminar in Foreign Language Instruction (3)
445. Teaching English to Dialect and Nonnative Speakers (3)
446. (Rl.St. 446) Western Religious Literature for Secondary School Teachers (3)
447. (Rl.St. 447) Eastern Religious Literature for Secondary School Teachers (3)
448. Language Teaching in School Programs (3)

541. Children's Literature Related to Ethnic and Social Issues (3) Children's literature, K-12; study of literary symbolism, ethnic literature, and controversial issues; bibliotherapy, censorship, sex education through the trade book. Prerequisite: L.Ed. 441.

542. Seminar in English Language Arts (3) Topics in curriculum development and research in elementary and secondary English education and teacher training. Instructional materials analysis and development. Prerequisites: L.Ed. 442 or 443, and teaching experience.

543. Research Problems in the Teaching of English (3) Cooperative study by specialists, teachers, and administrators of problems and research findings in the teaching of English in American schools. Prerequisites: L.Ed. 442 or 443, and teaching experience.

MATHEMATICS EDUCATION (MTHED)

420. Teaching Mathematics in the Elementary Schools (3)
421. Teaching Mathematics in the Secondary Schools (4)
422. Individualizing Instruction in School Mathematics (3)

424. Contemporary Elementary School Mathematics Programs (3)
425. Contemporary Secondary School Mathematics Programs (3)
427. Computers and the Teaching of Mathematics (3)

520. Analysis of Research in Mathematics Education (3) Survey of the status of knowledge about mathematics learning and instruction, K-12; analysis of research procedures; instruments for evaluating research. Prerequisites: Mth.Ed. 420 or 421, 3 credits in statistics, and teaching experience.

521. Strategies for Research in Mathematics Education (3) In-depth analysis of strategies for research in mathematics education; conditions for applying the scientific model; implications for research and development. Prerequisite: Mth.Ed. 520.

525. Research Participation in School Mathematics Curriculum Construction (3) Development of theoretical bases for the construction of instructional materials in mathematics, research participation in preparing and testing curriculum materials. Prerequisite: Mth.Ed. 521.

SCIENCE EDUCATION (SCIED)

455. Field Natural History for Teachers (3)
456. Teaching of Conservation of Natural Resources in the Schools (3)
457. Teaching of Environmental Education in the Schools (3)
458. Teaching Science in the Elementary School (3)
459. Teaching Science in the Secondary School (4)

556. The Supervision of Science Curriculum (3) Supervision of elementary and secondary science teachers as they develop K-12 programs in the public schools. Prerequisites: 6 credits in science methods, 20 credits in science or equivalent, and teaching experience.

557. (Biol. 557) Workshop in the Biological Sciences (3) Projects designed for teachers of biology in the secondary schools.

558. Research Problems in Science Teaching (3) Problems and research dealing with curriculum, materials, evaluation, and supervision of science teaching and learning. Prerequisites: Sci.Ed. 458 or 459, and teaching experience.

559. Analysis of Instruction in Elementary Science Education (3) Analysis of the history, issues, trends, and research in elementary science education. Prerequisites: teaching experience, 3 credits in elementary science methods, and 18 credits of science courses.

SOCIAL STUDIES EDUCATION (SS ED)

430. Teaching Social Studies in the Elementary Grades (2-3)
431. Teaching Social Studies in the Secondary Schools (4)
432. The Social Sciences in the Social Studies Curriculum (2-3)

530. Instructional Practices in the Social Studies (3) Social studies innovations in the classroom, new programs, new materials, new methods, and evaluation. Prerequisite: one year of teaching experience.

531. Problems in Elementary School Social Studies (3) Historical-philosophical bases for the social studies: curriculum development, research findings and techniques, learning resources, and promising proposals. Prerequisites: 400-level course in social studies methods and elementary school teaching experience.

532. Research Problems in Secondary School Social Studies (3) Rationale of the social studies curriculum for the middle and high school. Promising social studies programs for the adolescent. Prerequisites: a methods course in social studies and teaching experience.

533. Research in the Teaching of Social Studies (3) Procedures and methods of research for the teaching of social studies, strategies of investigation and review of research literature. Prerequisites: 12 credits in the social sciences on the 400 or 500 level and teaching experience.

ADMINISTRATION (ADMIN)

Robert J. Brown, *Chairman, Graduate Program in Administration at Capitol Campus*
Middletown, Pa. 17057

Degree Conferred: M.Adm.

Graduate Faculty: Senior Members Heindel and Lee.

Graduate Faculty: Associate Members R. Brown, T. Brown, Frey, Gilmore, McKenna, Murti, Murty, Poore, and Yager.

This program is intended to meet the professional needs of practicing and potential administrators. All students must satisfy (1) a series of prerequisites for each option, (2) 15 credits of common core courses, and (3) at least 15 credits of option area course work. Options are currently available in Business Administration and Engineering Administration. The Business Administration option is intended for those students who desire to pursue an administrative career in any phase of commerce, business, or industry. The Engineering Administration option is a quantitative program in management science and operations research.

The prerequisite requirements are an integral part of the program. Some or all of these requirements may be waived, based on equivalent work previously completed.

For Business Administration, prerequisite courses are required in micro- and macroeconomic analysis, advanced economic analysis (Econ. 405), finite mathematics, calculus, probability and statistics, accounting, finance, marketing, management, quantitative models, introduction to computer, and business law.

For Engineering Administration, prerequisite courses are required in micro- and macroeconomic analysis, advanced economic analysis (Econ. 405), finite mathematics, calculus, differential equations, quantitative models, linear algebra, probability and statistics, introduction to computer, accounting and finance, and graduation from an accredited undergraduate curriculum in engineering, mathematics, or physics.

For admission to the Master of Administration program, the student must have a baccalaureate degree from an accredited institution. Students with a 2.75 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.75 grade-point average may be made for students with special backgrounds, abilities, and interests.

Applicants are required to take the Admission Test for Graduate Study in Business.

The program is offered only at the Capitol Campus.

COURSES*

Econ. 404. Current Economic Issues (3)
Econ. 405. Advanced Economic Analysis (3)
Econ. 419. Case Studies in Labor-Management Relations (3)

Acctg. 511. Financial and Managerial Accounting (3)

Admin. 500. Administrative Theory (3) History, significance and functions of administration, theories of leadership, authority, decision making, rationality, and efficiency.

Admin. 510. Organization Behavior (3) Examination of concepts of human behavior in formal organizations, systems analysis, conceptual models, and decision processes.

*Course descriptions not given below will be found under the designated field of study.

ADMIN. 520. ADMINISTRATIVE MODELS (3) Formulation and solution of decision models for administrative problems. Analysis of decision making under certainty, risk, and uncertainty.

ADMIN. 540. ADMINISTRATIVE POLICY FORMULATION (3) Analysis of administrative problems from a total organization viewpoint. Case studies of actual organizations are used for analysis.

ADMIN. 550. PROGRAM PLANNING AND EVALUATION (3) Analysis and evaluation of public programs and systems from the perspectives of policy development and administrative planning and management.

ADMIN. 551. ADMINISTRATION AND THE POLITICAL PROCESS (3) Analysis of the relationship of administration to the political processes that shape public policy formulation and execution.

ADMIN. 553-554. RESEARCH METHODS IN ADMINISTRATION (3 each) Examination of research methodologies relevant to public administration. Student independently develops and executes a significant research project.

ADMIN. 555. GOVERNMENTAL FISCAL DECISION MAKING (3) Nature, function, and technique of governmental budgeting viewed as mechanism for allocating resources among alternative public uses.

ADMIN. 560. SAMPLING THEORY AND PRACTICE (3) Study of scientific method of obtaining representative samples, collection of information, techniques of estimation. Prerequisite: Math. 315.

ADMIN. 590. COLLOQUIUM (1-3)

ADMIN. 596. INDIVIDUAL STUDIES (1-6)

ADMIN. 597. SPECIAL TOPICS (1-6)

B.LOG. 538. LOGISTICS SYSTEMS MANAGEMENT (3)

FIN. 531. FINANCIAL MANAGEMENT (3)

I.B. 501. THE INTERNATIONAL ENVIRONMENT (3)

I.E. 508. OPERATIONS RESEARCH I (3)

I.E. 509. OPERATIONS RESEARCH II (3)

I.E. 510. MATHEMATICAL PROGRAMMING (3)

MGMT. 510. OPERATIONS MANAGEMENT (3)

MGMT. 540. PERSONNEL MANAGEMENT (3)

MKTG. 500. MARKETING MANAGEMENT (3)

MKTG. 530. CONSUMER AND MARKET BEHAVIOR (3)

PL.SC. 575. GOVERNMENT MANPOWER MANAGEMENT (3)

PL.SC. 576. GOVERNMENT FISCAL DECISION MAKING (3)

Q.B.A. 501. ADVANCED BUSINESS STATISTICS (3)

Q.B.A. 570. MANAGEMENT SCIENCE: IMPLEMENTATION AND CONTROL (3)

AEROSPACE ENGINEERING (AERSP)

BARNES W. MCCORMICK, *Head of the Department*
233 Hammond Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Arndt, Holl, Kaplan, Lakshminarayana, Lancaster, Lumley, McCormick, Phillips, Tennekes, and York.

Graduate Faculty: Associate Members Eisenhuth and Parkin.

Opportunities are available for graduate study in the following areas: low-speed aerodynamics, V/STOL aircraft, turbulence, geophysical fluid dynamics, astrodynamics, turbomachinery, aeroacoustics, plasma dynamics, rarefied gas dynamics, hydrodynamics, stability and control of aerospace vehicles, aeroelasticity, and aerospace structures.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by an intermediate knowledge of two foreign languages, by providing proof of mature and meaningful knowledge in a cultural subject of broad significance as a substitute for one of these languages, or by a comprehensive knowledge of one foreign language.

The entering student must hold a bachelor's degree in physical science, mathematics, or engineering and may be required to complete (without degree credit) undergraduate course work in fluid and solid mechanics and intermediate mathematical analysis, if he has not already done so. Students with a 2.70 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.70 grade-point average may be made for students with special backgrounds, abilities, and interests.

AEROSPACE ENGINEERING (AERSP)

401a,b,c. AEROSPACE ENGINEERING PROJECTS (1-12)
402. AEROSPACE DESIGN (2)
404. AEROSPACE ENGINEERING LABORATORY (2)
405. EXPERIMENTAL METHODS IN AEROSPACE ENGINEERING (3)
407. AERODYNAMICS OF V/STOL AIRCRAFT (3)
409. ADVANCED AEROSPACE STRUCTURAL MECHANICS (3)
410. AEROSPACE PROPULSION (3)
411. AEROELASTICITY (3)
412. TURBULENT FLOW (3)
413. STABILITY AND CONTROL OF AIRCRAFT AND MISSILES (3)
415. PHYSICAL GAS DYNAMICS (3-6)
416. INTRODUCTION TO RESEARCH AND DESIGN (1)
417. AEROSPACE THESIS (2)
420. PRINCIPLES OF FLIGHT TESTING (3)
421. (M.E. 421) INTERMEDIATE VISCOUS FLOW (3)
425. THEORY OF FLIGHT (3)
430. SPACE PROPULSION AND POWER SYSTEMS (3)
444. NOISE POLLUTION OF FLUID DYNAMIC ORIGIN (3)
450. ORBIT AND ATTITUDE CONTROL OF SPACECRAFT (3)

503. ELECTROMAGNETICALLY AND CHEMICALLY ACTIVE FLOWS (3) Flow of media which may be conductive, permeable, ionizable, or otherwise capable of interacting with imposed or self-generated fields.

504. AERODYNAMICS OF V/STOL AIRCRAFT (3) Jet wings, high lift devices, propellers and ducted propellers, circulation and boundary layer control, unsteady airfoil theory. Prerequisite: Aersp. 407.

505. Aero- and Hydroelasticity (3) Interaction of elastic systems having several degrees of freedom with fluid flows in various configurations.

506. Cavitation (3) Flow regimes, dynamics of cavitation, prediction of the minimum pressure in the fluid, scale effects, effect of surface irregularities.

507. Theory and Design of Turbomachinery (3) Theory and principles of machinery design: compressors, turbines, pumps, and rotating propulsors; opportunity to work out design examples.

508. Foundations of Fluid Mechanics (3) Mathematical review, fluid properties, kinematics, conservation laws, constitutive relations, similarity principles, the boundary layer, inviscid flow, vorticity dynamics, wave motion.

509. Dynamics of Ideal Fluids (3) Irrotational flow theory, two-dimensional and axisymmetric flows, airfoil theory, complex variables, unsteady phenomena; flow with vorticity, finite wing theory. Prerequisite: Aersp. 508.

510. Compressible Flow (3) Classification and solution of compressible flow problems, high speed gasdynamics, unsteady motion, transonic and hypersonic flows, atmospheric reentry.

511. Aerodynamically Induced Noise (3) Review of fluid mechanics. General theory of aerodynamic sound. Noise radiation from jets, boundary layers, rotors and fans. Structural response.

512. Viscous Flow (3) Stress-deformation relations; Newtonian fluids, Navier-Stokes equations; exact, asymptotic laminar solutions; instability, transition; similitude and turbulent boundary layer.

514. Stability of Laminar Flows (3) The stability of laminar motions in various geometries as influenced by boundary conditions and body forces of various kinds.

515. Foundations of Turbulence (3) The mathematics underlying turbulence theory: descriptions, kinematics of stochastic fields; techniques of solution of linear and some nonlinear problems.

516. Homogeneous Turbulence (3) Dynamics: production, spectral transfer, dissipation, decay of energy; similarity theories.

517. Inhomogeneous Turbulence (3) Dynamics: similarity, structural hypotheses; spatial, spectral budget of energy in a number of classical flows.

518. Dynamics and Control of Aerospace Vehicles (3) Dynamical problems of aircraft and missiles including launch, trajectory, optimization, orbiting, reentry, stability and control, and automatic control. Prerequisite: Aersp. 413 or 450.

550. Astrodynamics (3) Applications of classical celestial mechanics to space flight planning. Determination and construction of orbital parameters by approximation methods. Perturbation techniques. Prerequisite: Aersp. 450 or Astro. 460 or E.Mch. 410 or Phys. 419.

590. Colloquium (1-3)

596. Individual Studies (1-6)

597. Special Topics (1-6)

AGRICULTURAL ECONOMICS (AG EC)

LEE M. DAY, *Head of the Department of Agricultural Economics and Rural Sociology*
6A Weaver Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members Becker, Bennett, Brandow, Day, Frey, Gamble, Hutton, Jansma, Madden, McAlexander, Partenheimer, Pasto, Pierce, Stemberger, and Trotter.

Graduate Faculty: Associate Members Epp, Hallberg, Herrmann, Holt, and Schutjer.

The graduate program emphasizes economic theory and analytical techniques in the fields of farm management, production economics, agricultural marketing, resource economics, rural development, agricultural policy and prices, and in international agricultural trade and development.

There is no foreign language requirement for the Ph.D. degree; rather, the student must satisfactorily complete courses in economic theory and quantitative methods.

Students entering the M.S. program should have 3 credits in agricultural economics, 3 credits in economics, and 3 additional credits in either field. Students entering the Ph.D. program should have successfully completed courses in intermediate micro- and macroeconomic theory, in differential and integral calculus and linear algebra, and in introductory statistics. Students are permitted to enter the M.S. and Ph.D. programs with deficiencies but must pass courses to eliminate deficiencies as soon as possible.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

AGRICULTURAL ECONOMICS (AG EC)

407. ADVANCED FARM MANAGEMENT (3) *Mr. Partenheimer*
410. AGRICULTURAL FINANCE AND APPRAISAL (3) *Mr. Holt*
420. AGRICULTURAL PRICES (3) *Mr. Bennett*
421. LAND ECONOMICS (3) *Messrs. Frey and Gamble*
422. LAND AND WATER RESOURCE POLICY (3) *Mr. Jansma*
450. INTERNATIONAL AGRICULTURAL TRADE AND DEVELOPMENT (3) *Mr. Schutjer*
460. INDUSTRIAL ORGANIZATION IN FOOD PROCESSING AND DISTRIBUTION (3) *Mr. Brandow*
461. DECISION MAKING IN AGRICULTURAL MARKETING FIRMS (3) *Mr. Stemberger*

500. SEMINAR IN AGRICULTURAL ECONOMICS (1-6) Review of current literature and problems.

504. SEMINAR IN AGRICULTURAL POLICY (3) Analysis of farm prices, income consequences for producers and consumers, and effects on resource use; evaluation of policy, considerations in policy making. Prerequisites: Ag.Ec. 420, Econ. 405. Odd years. *Mr. Brandow*

505. ADVANCED AGRICULTURAL STATISTICS (3) Multiple correlation, curve fitting, analysis of variance, and other techniques applicable to the rural social sciences. Prerequisite: 3 credits in statistics. *Mr. Bennett*

507. SEMINAR IN FARM MANAGEMENT (1-6) Special problems relating to organization and operation of the farm business. Prerequisites: Ag.Ec. 6, Econ. 14. *Mr. Partenheimer*

509. CONCEPTS OF ECONOMETRIC THEORY (3) Concepts underlying the application of econometric methods to economic problems; identification and multiple equation models; hypothesis testing and decision theory. Prerequisites: Econ. 502, 503. *Mr. Hallberg*

514. Survey Research Techniques in Agricultural Economics (3) Survey methods and design of samples for obtaining economic data from business-unit and household populations. Prerequisite: Ag. 400. Odd years. *Mr. Bennett*

515. Economic Problems in the Marketing of Dairy Products (3) Economic problems as they are encountered in the process of marketing; particular attention to governmental regulation in pricing and marketing. *Mr. Pierce*

520. Farm Price Analysis (3) Econometric analysis of prices, production, and utilization of farm products; review of research in this field. Prerequisites: Ag.Ec. 420, 505; Econ. 405. Even years. *Mr. Hallberg*

524. Resource Economics (3) Economic aspects of resource use and development: economic growth, land-use planning and control, conservation, resource investment criteria and policies. Prerequisite: Ag.Ec. 421 or 422. *Mr. Epp*

525. Research Methods in Rural Social Sciences (2) Scientific method in planning and conducting research. Prerequisite: 9 credits in social sciences. *Mr. Brandow*

527. Seminar in Applied Quantitative Methods (1-4) *Messrs. Hallberg and Partenheimer*

534. Agricultural Production Economics (2) Economic theory applied to agricultural production problems: resource combinations, firm size, uncertainty and expectations, aggregate aspects of production, technological change. Prerequisite: Econ. 502. *Mr. Partenheimer*

550. Food Consumption Economics (3) Demand theory and research methods applied to the market for foods. *Mr. Herrmann*

571. Seminar in Land and Water Resource Economics (3) Critical review of research in resource economics; consideration of special topics in resource use.

AGRICULTURAL EDUCATION (AG ED)

David R. McClay, *Head of the Department*
102 Armsby Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members McClay, Stevens, and Stinson.

Graduate Faculty: Associate Members Anthony, Curtis, and Hoover.

Graduate programs emphasize the professional improvement of teachers. They provide advanced preparation for employment in administration, supervision, teacher education, and research in agricultural education and related fields. A minor may be taken in an area of agricultural science, technology, business, or in general studies. Programs may include courses needed for certification in other fields of education.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by an intermediate knowledge of two foreign languages, by substitution of courses from other designated areas for one of these languages, or by a comprehensive knowledge of one foreign language.

Prerequisite to admission is a minimum of 18 credits in professional education courses or certification as a teacher of agriculture. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

AGRICULTURAL EDUCATION (AG ED)

400v. Educational Programs in Agriculture for Developing Countries (3)

418v. Survey of Vocational Education in Agriculture (1-4)
420v. Instructional Media in Agriculture (1-6)
422v. Supervision of Vocational Education in Agriculture (1-4)
424v. Occupational Guidance in Agricultural Industry (1-4)
426v. Adult Education in Agriculture (1-4)
434v. Agricultural Developments (1-6)

501v. Agricultural Education in the United States (1-3) Historical development, social and philosophical foundations, and current status in relation to the total vocational-technical education program.

502v. Teaching Agriculture (1-3) Vocational education objectives, learning theory, class instruction, cooperative occupational experience, and evaluation.

508v. Administration and Supervision of Agricultural Education (1-3) Administration of state and district systems of vocational-technical education; supervision of teachers of agriculture.

509v. Teacher Education in Agriculture (1-6) Organization and administration of university programs of teacher education in agriculture, including preservice preparation, continuing education, research, and other services.

520v. Scientific Method in the Study of Agricultural Education (1-4) Methods of procedure in investigation and experimentation in education, accompanied by a critical examination of studies made in agricultural education.

521v. Scientific Method in the Study of Agricultural Education (1-4) Continuation of Ag.Ed. 520v; emphasis upon statistical techniques for students' individual problems.

524v. Program Development in Agricultural Education (1-3) Analysis of occupational needs of students and employment prospects; organization of courses of study and other activities of teachers.

530. Agricultural College Teaching (3) Selection and organization of subject matter for specific courses, methods of learning, teaching devices, techniques of teaching, and measurement of results of teaching.

590v. Colloquium (1-3)

596v. Individual Studies (1-6)

AGRICULTURAL ENGINEERING (AG E)

Frank W. Peikert, *Head of the Department*
250 Agricultural Engineering Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Aldrich, Mohsenin, Peikert, and Persson.

Graduate Faculty: Associate Members Bartlett, Butler, Keppeler, Kjelgaard, Morrow, Myers, Schroeder, and Stephenson.

Graduate programs are available in the areas of physical properties of agricultural materials; plant and animal environmental engineering; agricultural processing and food engineering; agricultural mechanization with emphasis on forage, fruits, and vegetables; rural sanitation and conservation engineering; and computer technology applied to agricultural engineering problems.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by either (1) 9 credits of courses in humanities and social science or (2) a foreign language.

Excellent facilities, including equipment and instrumentation, are available for research in the designated areas. Among the special facilities are freeze-drying equipment for drying by

sublimation, controlled environmental chambers, plant growth structures for modified atmosphere, a general purpose analog computer, and a laboratory for research on mechanical and rheological properties of agricultural materials. Laboratories are available with universal testing machines, equipped with accessories such as programmers and environmental chambers; a polariscope for photoelastic stress analysis; and acoustical and light reflectance instrumentation for research on the physical and rheological properties of agricultural materials.

Prerequisite to major work is the completion of an undergraduate major in engineering. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

AGRICULTURAL ENGINEERING (AG E)

400. Agricultural Engineering Problems (1-7)
401. Farm Mechanics for Teachers of Vocational Agriculture (1½-9)
402. Functional Design of Agricultural Structures (3)
403. Physical Properties of Agricultural Materials (3)
404. Agricultural Machinery (3)
405. Agricultural Process Engineering (3)
407. Soil Water Engineering (3)
408. Instrumentation for Agricultural Production and Processing (3)
409. Agricultural Systems Engineering (3)
410. Power for Agricultural Systems (3)
412. Physical Processes in Food Manufacturing I (3)
413. Physical Processes in Food Manufacturing II (3)
414. Physical Processes in Food Manufacturing III (2)
420. Seminar (1)
423. Physical and Rheological Measurements on Biomaterials (3)

500. Advanced Electro-Agriculture (1-6) Investigations in the application of electrical energy to processing, storing, and handling agricultural products. Seminar, written reports.

501. Advanced Farm Machinery (1-6) Application of agricultural engineering principles to design and operation of farm machinery. Prerequisite: Ag.E. 410.

502. Farm Structures Problems (1-6) Analysis of farm structures design problems.

503. Physical Properties of Plant and Animal Products (3) Physical characteristics; mechanical, rheological, thermal, electrical, and optical properties in relation to handling, storage, processing, and quality evaluation.

505. Experimental and Applied Instrumentation (4) The theory and application of electronics for instrumentation and experimental research.

507. Problems in Soil Water Engineering (1-6) Analysis of engineering problems relating to irrigation, drainage, or erosion control.

508. Advanced Problems in Farm Mechanics (1-15) Problems in farm shop practice and agricultural engineering related to the farm mechanics program of vocational education in agriculture. Prerequisites: Ag.E. 8, 14; or teaching experience in farm mechanics.

509. Research in Agricultural Engineering (1-4)

520. Agricultural Engineering Seminar (1-3) Reports on research and special topics.

AGRONOMY (AGRO)

JAMES L. STARLING, *Head of the Department*
117 Tyson Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members Baker, Barnes, Cleveland, Cunningham, Duich, Fortmann, Harrington, Hill, Hunter, Jung, Kardos, Kendall, Marshall, Matelski, McKee, Petersen, Starling, Thomas, and Washko.

Graduate Faculty: Associate Members Bollag, Ciolkosz, Cole, Fritton, Hall, L. Johnson, M. Johnson, Marriott, Pfeifer, Risius, Shenk, Waddington, and Watschke.

Students may specialize in soil science, crop science, or soil and crop management. Soil science specialties include genesis and morphology, chemistry, biochemistry, fertility, mineralogy, physics, and remote sensing. Crop science specialties include breeding and genetics, crop quality, crop and weed ecology, and physiology.

The communication and foreign language requirement for the Ph.D. degree may be met either by demonstrating a knowledge of at least one foreign language or by completing at least 6 credits of course work in an area of English communications approved by the student's advisory committee.

Prerequisites for major work in agronomy vary with the area of specialization and the degree sought, but courses in chemistry, mathematics, physics, geology, basic and applied biological sciences, and English communication skills are required. Applicants for the M.S. degree should have a baccalaureate degree including 76 credits of basic and applied natural sciences. For the M.Agr. degree program, an applicant must present a baccalaureate degree in agricultural or forest science. Admission to the Ph.D. program requires an M.S. or equivalent degree, and 100 credits (including credits of the baccalaureate degree) of basic and applied natural sciences. Students who lack some of the prerequisite courses may be admitted but are required to take these courses without degree credit.

A minimum cumulative undergraduate grade-point average of 2.80 is required for admission to the agronomy master's degree programs. Exceptions to this minimum may be made for students with special backgrounds, abilities, and interests. Applicants for the Ph.D. program will be evaluated principally on the quality of work completed in previous graduate programs. The best-qualified applicants will be accepted up to the number of spaces that are available for new students.

AGRONOMY (AGRO)

401. SOIL COMPOSITION AND PHYSICAL PROPERTIES (3)
402. CHEMISTRY OF SOILS AND FERTILIZERS (3)
410. CROP SCIENCE (3)
411. BREEDING OF FIELD CROPS (3) *Mr. Cleveland*
415. SOIL MORPHOLOGY, MAPPING, AND LAND USE (3) *Mr. Petersen*
416. SOIL GENESIS AND CLASSIFICATION (3) *Mr. Ciolkosz*
417. FOREST SOILS (3) *Mr. Pennock*
420. AGRONOMIC CASE STUDIES IN SOIL, PLANT, AND WATER MANAGEMENT (3)
423. FORAGE CROP MANAGEMENT (3) *Mr. Washko*
425. FIELD CROP MANAGEMENT (3) *Mr. Pfeifer*
438. PRINCIPLES OF WEED CONTROL (3) *Mr. Hartwig*
496. SPECIAL TOPICS IN AGRONOMY (1-6) *Mr. Washko and Staff*

501. ADVANCED SOIL FERTILITY (4) Interpretation of fertility experiments and diagnosis of soil-plant relationships through field appraisal, analysis, and plant symptoms. Prerequisites: Agro. 431, Biol. 441. *Mr. Hall*

503. Agronomy Seminar (1) Weekly meeting where papers and discussions will be presented by students and staff members.

506. Soil Chemistry (4) Analyses of important chemical and biochemical reactions occurring in soils, conditions which control these reactions and their importance in soil genesis and plant growth; laboratory work in the more typical and significant analytical procedures; lectures, review of current literature, and practicum. Prerequisites: Agro. 419; Bioch. 425 or Chem. 451. *Mr. Baker*

507. Soil Physics (4) Physical properties of the soil; factors affecting them; their measurements, evaluation, and influence in determination of soil productivity. Prerequisites: Agro. 419, Bioch. 425, Phys. 215. *Mr. Fritton*

509. Genetics of Crop Plants (3) Inheritance in crop plants with particular reference to factor interaction, genetic aspects of linkage and crossing-over, quantitative inheritance, and heterosis. Prerequisite: Biol. 422. *Mr. Cleveland*

510. The Application of Cytogenetics to Plant Breeding (3) Cytogenetics, including chromosome structure and behavior, chromosome alterations, polyploidy, interspecific hybridization, and their applications to plant breeding. Prerequisite: Biol. 422. *Mr. Cleveland*

512. Field Plot Technique (4) Ramifications of analysis of variance techniques; combining and analyzing data from several experiments; selection of valid error terms. Prerequisite: Stat. 200 or Ag. 400. *Mr. Risius*

516. Humus (2) Origin and chemical nature of soil organic matter, its importance in soil processes, and its decomposition. Prerequisites: Agro. 419, 431.

517. Farm Crops Ecology (3) Ecological factors affecting growth and development of farm crops with particular reference to effects of altered environment and management practices. Prerequisites: Agro. 28, Biol. 441. *Mr. McKee*

518. Growth and Management of Forage Crops (3) Factors affecting growth and development of forage crops with particular reference to effects of environment, defoliation, and management practices. Prerequisites: Agro. 423, Biol. 441. *Mr. McKee*

519. The Nature of Soil Minerals (3) Modern methods for identification of the constituent minerals of soils and their relation to soil classification and agricultural practices. Prerequisites: Agro. 419, G.Sc. 23. *Mr. Johnson*

545. The Application of Statistics to Field Experiments (4) Use of advanced experimental designs in planning, analyzing, and interpreting experiments; includes lattice designs, factorials, confounding, simple and multiple covariance techniques. Prerequisite: Agro. 512. *Mr. Starling*

*550. Agronomic Problems (1-12) Provides training in selected areas of agronomy by means of supervised investigations or studies.

582. Seminar in the Breeding and Genetics of Farm Crops (1 per term)

AMERICAN STUDIES (AM ST)

Irwin Richman, *Chairman, Social Science Program*
The Capitol Campus, Middletown, Pa. 17057

Degree Conferred: M.A.

Graduate Faculty: Senior Members Lear, Richman, Tischler, G. Wolf, and M. Wolf.

Graduate Faculty: Associate Members Anderson, Eisenstein, Knight, McAree, and Patterson.

This program emphasizes the study of American society as a whole, not as interpreted by a single discipline, but in the larger context of a culture. The purpose of the program is to provide the student with the opportunity to acquire knowledge and understanding within any of the

*Credits 1-6 per term.

following areas: ethnic composition and demographic problems of the American people; regional characteristics; the technological base of American civilization; economic, political, and social institutions; the media of communication; artistic expression, particularly in art, architecture, literature, and music; philosophy and values; and the dynamics and interrelationships of all of these.

The student is required to take a minimum of 30 credits, including at least 18 credits in the 500 series. A maximum of 24 of these 30 credits shall be taken within the program area. An original, scholarly master's paper or creative production initiated by the student, supervised by an appropriate professor, and judged by a committee is required. One to six credits can be accumulated during work on the master's production.

For admission to the master's program, a student must have received a baccalaureate degree from an accredited institution, earned under residence and credit conditions substantially equivalent to those required by The Pennsylvania State University. Social sciences or the humanities are not required as prerequisites, though it is anticipated that students will have had work in these areas. The application, transcripts, and a letter outlining personal goals and reasons for applying for the program should be sent directly to the Graduate Office, The Capitol Campus, Middletown, Pa. 17057.

REQUIRED COURSES

Am.St. 500. Theory and Methods (3) Study of the methods and materials of American Studies scholarship, compilation of bibliographies, the writing of scholarly papers, and proper documentation.

Am.St. 580. Production in American Studies (1-6) An original and independent exploration of some area of American Studies.

APPROPRIATE COURSES may be taken from the following list and from 500-level courses in other fields with the concurrence of the student's adviser.

Am.St. 511. Pivotal Books (3) Exploration of a number of books which have been particularly influential in shaping thinking about American civilization.

Am.St. 530. Material Culture (3) Consideration of the techniques for studying material culture and of historical and regional patterns of material culture in America.

Am.St. 533. American Civilization in the Eighteenth Century (3) Detailed investigation of specific topics in eighteenth-century American civilization.

Am.St. 534. American Civilization in the Nineteenth Century (3) Representative interdisciplinary investigation of social, historical, economic, and aesthetic forces predominant in nineteenth-century America.

Am.St. 535. American Civilization in the Twentieth Century (3) Detailed investigation of specific periods or topics in twentieth-century American civilization.

Am.St. 569. American Science and Medicine Prior to the Civil War (3) An exploration of how scientific and medical thought mirrors the emergence of American culture.

Am.St. 590. Colloquium (1-3)

Am.St. 596. Individual Studies (1-6)

Am.St. 597. Special Topics (1-6)

ADDITIONAL COURSES may be taken from the following list and from 400-level courses in other fields with the concurrence of the student's adviser.*

Am.St. 401. Foundations of American Civilization
Am.St. 422. Western Movement
Am.St. 431. The American Character
Am.St. 442. American Folklore
Am.St. 445. American Philosophy
Am.St. 451. Civil War and Reconstruction
Am.St. 452. The American Renaissance
Am.St. 453. The Gilded Age and the Progressive Impulse

*Descriptions of these courses may be found in *The Capitol Campus Catalog.*

Am.St. 454. America's Political Parties
Am.St. 455. Realism and Naturalism in American Society
Am.St. 456. Mass Culture: The Popular Arts in America
Am.St. 457. Immigrants and Americans
Am.St. 458. Contemporary America
Am.St. 459. America's Coming of Age 1914-1939
Am.St. 460. American Art and Architecture
Am.St. 463. American Music
Am.St. 470. Regionalism in America
Am.St. 471. The American Political Novel
Am.St. 474. (Econ. 474) American Economic Development
Am.St. 479. United States Diplomatic History
Am.St. 480. Museums and Culture
Am.St. 491. Senior Seminar in American Culture
Am.St. 498. Special Topics
So.Sc. 402. Studies in American Society
So.Sc. 403. Contemporary U.S. Foreign Policy
So.Sc. 470. The Presidency and the Executive Process

ANATOMY (ANAT)

Bryce L. Munger, *Chairman of the Department*
The Milton S. Hershey Medical Center
Hershey, Pa. 17033

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Baird, Munger, B. Pubols, and L. Pubols.

Graduate Faculty: Associate Members Leure-duPree and McCallister.

The graduate program emphasizes the general areas of gross anatomy, histology/cytology, neuroanatomy/neurophysiology, or appropriate combinations of these areas. Approaches offered include morphological (descriptive, comparative, developmental), functional (physiological, chemical), and experimental. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

A bachelor's degree reflecting a reasonable background in zoology or biology, mathematics, and chemistry is required. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for the students with special backgrounds, abilities, and interests. Applicants must provide complete transcripts and two letters of recommendation. Scores from the Graduate Record Examination and a personal interview are desirable.

This program is offered only at The Milton S. Hershey Medical Center.

ANATOMY (ANAT)

501. Gross Human Anatomy (3) Macroscopic organization of the extremities and head and neck with emphasis on anatomical individuality, functional significance, and clinical correlations.

502. Gross Human Anatomy (6) An intensive study of the macroscopic organization of the human body. Primarily for graduate students.

505. Microscopic Anatomy (3) Microscopic organization of tissues and cells; interrelationships of cells; chemical and functional specializations of cells.

510. NEUROBIOLOGY (3) Morphology and function of the sense organs, general organization of the brain, and physiological studies of central nervous system function.

512. HUMAN EMBRYOLOGY (2) A basic study of the development of the human embryo including gamete production and fusion, implantation, and organogenesis.

530. DISSECTION (2-4) Intensive laboratory study of selected regions of the human body. Coverage and credit arranged by consultation.

535. SUBMICROSCOPIC ANATOMY (3) Current literature on molecular and micellar organization of cells and tissues in diverse systems; application of interference and electron microscopy. Prerequisite: Anat. 505.

540. SEMINAR (1 per term) Student and staff presentations designed to evaluate current research developments in anatomy.

542. COMPARATIVE NEUROLOGY (3) Topics in functional anatomy and neurophysiology. The comparative approach to the organization of the mammalian nervous system will be stressed. Prerequisite: Anat. 510.

543. SENSORY PROCESSES (3) Morphological, physiological, and psychophysical aspects of mammalian sensory systems; emphasizing somatic sensory, visual, and auditory systems. May be repeated. Prerequisite: Anat. 510.

545. COMPARATIVE AUDITORY AND VISUAL ANATOMY (3-5) An introduction to the morphology and evolution of the vertebrate eye and ear; individualized laboratory work arranged by consultation.

550. SEMINAR IN QUANTITATIVE OPTICS (3) Study of the various types of light microscopy instruments and application of these tools to quantitative measurements in biological systems. Prerequisite: Anat. 505.

570. SPECIAL TOPICS (1-6) Introduction of students to the research laboratory and scholarly pursuits of members of the staff; credit arranged by consultation.

590. RESEARCH PROBLEMS (1-12) Individualized research conducted by students in departmental laboratories. The program and credits to be arranged by consultation.

ANIMAL INDUSTRY (A I)

B. R. BAUMGARDT, *Head of the Department of Animal Science*
325 Animal Industries Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members Baumgardt, Cowan, Gobble, Hershberger, Long, Martin, Sink, Wilson, and Ziegler.

Graduate Faculty: Associate Members Cash, Merritt, Sherritt, and Wangsness.

Opportunities are available for graduate study and research in breeding and genetics, nutrition and feed technology, physiology, animal management systems, growth and body composition, and meat science and processing technology. Ruminant, nonruminant, small animal, and wildlife species are available.

The M.Agr. is a professional program designed to prepare individuals for specialist and management positions in county agricultural extension, government, or industry, and does not require a thesis. The academic M.S. and Ph.D. programs require a thesis and are designed for those primarily interested in education and research. The requirements of these programs are detailed in the departmental publication, *Requirements of the Graduate Programs in Animal Industry.* The communication and foreign language requirements for the Ph.D. degree may be satisfied by competence in either one foreign language or communications skills.

For admission the student must complete an undergraduate major in animal science or a closely related field. Students who lack some of the course prerequisites may be admitted but

are required to take the prerequisite courses without degree credit. Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests.

ANIMAL INDUSTRY (A I)

400. Special Topics (1-6)
405. Meat Animal Management (4)
421. Science of Meat (3)
423. Advanced Livestock Selection (2)
424. Animal Industry Seminar (1)
431. Advanced Meat Selection and Grading (2)

501. Pedigree Study (1-6) Research work in breed study history, and analytical study of breed pedigrees, and a complete survey of the herd, flock, or stud book.

502. Research in Meats (1-6 per term) Investigation of methods for handling, cutting, processing, freezing, and curing meat and meat products. Prerequisite: A.I. 421.

505. Advanced Animal Breeding (1-5) Special problems in animal genetics as applied to breeding and improvement of horses, cattle, sheep, and swine. Prerequisite: An.Sc. 322.

510. Animal Science Research Methods (3) Application of scientific method; experimental design and procedures; analyzing, interpreting, and reporting research results. Prerequisite: Ag. 400.

514. Animal Growth and Development (3) Animal life cycles; nature of growth and development; effects of biological, environmental, social, and psychological variants; homeostasis and organismic theory. Prerequisites: 3 credits in biochemistry and 3 credits in physiology.

590. Colloquium (1-3)

596. Individual Studies (1-6)

597. Special Topics (1-6)

Note: *See Animal Nutrition and Food Science. Also see Animal Science under "Other Elective Graduate Courses."*

ANIMAL NUTRITION (A NTR)

Roland M. Leach, *Chairman of the Committee on Animal Nutrition*
205 Animal Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Baumgardt, Cowan, Gobble, Hartsook, Hershberger, Kesler, Kollias, Leach, Long, Martin, McCarthy, Mendez, and Mueller.

Graduate Faculty: Associate Members Scholz, Shellenberger, and Wangsness.

This is an interdepartmental graduate program designed to enable students to obtain thorough training in animal nutrition. The program is under the direction of a committee composed of graduate faculty members of the Departments of Animal Science, Dairy Science, Poultry Science, Veterinary Science, and the Human Performance Research Laboratory. Programs are offered in ruminant and nonruminant nutrition, including: physiology of nutrition; nutritional requirements for productive functions; metabolism of carbohydrates, lipids, proteins, vitamins, and minerals; and regulation of food intake and other metabolic functions.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign languages.

Undergraduate preparation should include organic and analytical chemistry, physics, biology, and mathematics. Students may be admitted with limited deficiency but are required to make up undergraduate deficiencies without graduate credit.

Students should have an appropriate background and a 3.00 average in the major area and in related sciences for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum requirements may be made for students with special backgrounds, abilities, and interests.

The following nutrition courses are offered by participating departments, and their descriptions may be found under the listings of the respective departments: D.Sc. 511, Pty.Sc. 502, and V.Sc. 535. Courses related to animal nutrition can be found under the following listings in this bulletin: Animal Industry, Biochemistry, Dairy Science, Food Science, Physiology, Poultry Science, and Veterinary Science. For other graduate courses in this subject area see courses listed under Nutrition such as Nutr. 552, 556, and 557.

ANIMAL NUTRITION (A NTR)

400. Nutrition and Feed Technology (3)
401. Physiology of Nutrition (3)
402. Energy and Protein Metabolism (3)

501. Energy Metabolism (2) Integration of biochemical and physiological processes in energy metabolism; concepts underlying the application of bioenergetics and calorimetry to body functions. Prerequisites: 3 credits each in biochemistry and physiology.

503. Micronutrients: Nutrition, Metabolism, and Function (2) Functional approach to the study of vitamins and trace elements in the nutrition and metabolism of animals and man. Prerequisites: 3 credits each in biochemistry, nutrition, and physiology.

505. Ruminology (3) Physiological, biochemical, and microbiological activities occurring within the rumen and the relation of rumen function to animal response. Prerequisites: at least one course in each of the following areas: animal nutrition, physiology, microbiology, and biochemistry.

590. Colloquium (1-3)

596. Individual Studies (1-6)

597. Special Topics (1-6)

ANTHROPOLOGY (ANTHY)

Warren T. Morrill, *Head of the Department*
409 Social Sciences Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Baker, Chagnon, Escobar, Hunt, Matson, Michels, Morrill, and Sanders.

Graduate Faculty: Associate Members Dyke, Eckhardt, Nydegger, and Webster.

The master's program is designed to train students in general anthropology. The doctoral program is structured to train students in the following areas of specialization: new world archaeology, middle eastern archaeology, archaeological methodology, physical anthropology with special emphasis on human ecology; cultural ecology; Latin American ethnology; and peasant society.

M.A. candidates may submit either a thesis or a term paper. If the latter is chosen, 6 credits in 500-level courses in the major field must be scheduled in lieu of thesis credits. The M.A. degree may be bypassed by exceptional candidates for the Ph.D. degree.

The communication and foreign language requirement for the Ph.D. degree includes a reading knowledge of a foreign language plus an option from among additional foreign languages, field languages, linguistics, and statistics.

Undergraduate preparation must include 12 credits in anthropology and archaeology or their equivalent. A student with an excellent record but who does not meet these requirements may be admitted provided he makes up course deficiencies without graduate credit. Students with a 3.00 or above junior-senior average and with appropriate course backgrounds who have research interests directly related to the special anthropological competences within the department will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

ANTHROPOLOGY (ANTHY)

400. Human Evolution: The Material Evidence (3)
401. Human Evolution: Theory and Process (3)
402. Human Ecology (3)
405. Primatology (3)
408. Demographic Methods in Anthropology (3)
409. Analytic Methods Laboratory (1)
415. (C.F.Ed. 415) Anthropology of Education (3)
420. Archaeology of the Near East (3)
421. Archaeology of the Central Andes (3)
422. Archaeology of Meso-America (3)
423. Archaeology of Eastern United States (3)
424. Archaeology of Africa (3)
440. South American Tribal Societies (3)
441. Ethnology of the Andean Region (3)
442. European Peasantry (3)
444. Ethnology of Meso-America (3)
446. Ethnology of North America (3)
447. Ethnology of Sub-Saharan Africa (3)
449. Ethnology of Southeast Asia (3)
450. Comparative Social Organization (3)
451. Economic Anthropology (3)
452. The Anthropology of Hunting Societies (3)
453. (Soc. 453) Primitive Religion (3)
454. Political Anthropology (3)
455. Culture and Personality (3)
456. Cultural Ecology (3)
457. Language in Culture (3)
460. Anthropological Theory (3)
461. Methods in Cultural Anthropology (3)
462. Methods in Archaeology (3)
463. Field Linguistics (3)
471. History of Anthropological Theory (3)

501. Evolution of Human Behavior (3) The application of evolutionary theory to the study of man's structure, function, and culture. Prerequisites: Anthy. 21 or 401, and 3 additional credits in anthropology, sociology, or psychology.

502-503. Ecological Theory in Anthropology (3 each) Man's biology, culture history, and culture variation from the ecological perspective. Two-term enrollment required. Prerequisite: 6 credits in anthropology.

504. Social and Cultural Change (3) Theories and methods used in the analysis of social and cultural change.

505. Naturalistic Behavior of Nonhuman Primates (3) Comparative study of behavior including taxonomy, geographic distribution, ecology, territoriality, population composition, grouping patterns, individual and group interactional characteristics, communication.

506. Cultural Dynamics (3) Survey of the major theories of culture change with special reference to archaeological research.

507. The Biology of Human Adaptability (3) An exploration of the biological mechanisms which aid man's survival in a variety of environmental settings.

508. Research Problems in Culture History (3-9)

509. Seminar in Regional Studies (3-9) Research and analysis in selected world cultural areas, including ecology, prehistory, history, ethnography, and current status.

510. World Ethnographic Survey (3) General survey of world cultures and their historical development.

511. (Hl.Ed. 511) Health Implications in the Growth and Development of School Children (3) Child growth and development emphasis for teachers; medical inspection and examination; preschool program; early habit formations; behavior problems.

513. (Hl.Ed. 513) Health Implications in Maturity and Aging (3) Changes in the human body in maturity and aging; mechanisms of physiologic aging; implications for health and preventive medicine.

530. Individual Readings in Anthropology (1-6) Reading or research in selected aspects of general anthropology.

531. Individual Research in Anthropology (3-6)

545. Seminar in Anthropology (1-9) Critical analysis of research in selected areas of anthropology.

560. Anthropological Theory (3) Theory used in culture-historical, sociological, and psychological interpretations.

561. Field Methods in Anthropology (3-9) Individual field work in any aspect of anthropology, supervised by staff of professional rank.

562. Laboratory Methods in Anthropology (3-9) Supervised laboratory research, utilizing materials from physical anthropology or archaeology or cultural anthropology.

563. Seminar in Linguistic Anthropology (3-6) Organized research on special topics in linguistic anthropology.

597. Special Topics (1-6)

ARCHITECTURAL ENGINEERING (A E)

Gifford H. Albright, *Head of the Department*
101 Engineering A Building

Degree Conferred: M.S.

Graduate Faculty: Senior Members McLaughlin and Tichy.

Graduate Faculty: Associate Members Albright, Summers, and Wheeler.

Students may specialize in structural analysis and design, environmental control engineering (including energy conservation and energy management in building), solar energy applications, illumination, acoustics, materials of construction, building construction management, computer application to building design and performance, or nuclear defensive and protective construction. The latter area includes shelter planning, effects of nuclear weapons, shelter environmental

requirements, analysis and design of blast-resistant structural systems, and integrated engineering requirement for protective construction.

For admission a student must have a strong background in some field of engineering; in engineering science or mechanics; or in architecture, psychology, economics, or management if there is adequate preparation in the physical sciences and mathematics. The detailed requirements depend upon the student's area of special interest.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

ARCHITECTURAL ENGINEERING (A E)

401. Architectural Engineering (3)
402. Architectural Engineering (3)
403. Architectural Engineering (3)
430. Architectural Engineering (3)
431. Architectural Engineering (3)
439. Architectural Engineering (3)
441. Integration of Architectural Engineering Systems (3)
442. Research in Architectural Engineering (1-6)
454. Environmental Engineering Buildings — Design (3)
458. Advanced Architectural Acoustics and Noise Control (3)
464. Advanced Architectural Illumination Systems Design (3)
471. Building Construction Assemblies (3)
472. Building Construction Management I (3)
473. Building Construction Management II (3)
474. Building Cost Analysis (3)
475. Building Construction Engineering I (3)
476. Building Construction Engineering II (3)
477. Building Project Analysis (3)
481. Architectural Engineering Thesis (2)
482. Architectural Engineering Thesis (2)
483. Architectural Engineering Thesis (2)
486. Professional Engineering Practice (3)

502. Architectural Engineering (3-8) Advanced structural design in steel and reinforced concrete. Lectures and class criticism. Practicum and seminar.

542. Advanced Problems and Research in Architectural Engineering (2-12) Investigation, analysis, and preparation of comprehensive report on subject relating to special problems in architectural engineering systems.

545. Architectural Engineering Seminar (1-6) Current literature and special problems in architectural engineering; presentation of technical papers.

551. Advanced Nuclear Defense Planning and Design I (3) Weapons effects data; dynamic strength of materials and structural elements; dynamic design; architectural, structural, electrical, and mechanical requirements for shelters. Prerequisites: A.E. 4, 5; E.Mch. 12.

552. Advanced Nuclear Defense Planning and Design II (3) Blast-resistant design of framed structures, shear wall structures, arches, domes, and underground structures; radiation shielding characteristics of building materials. Prerequisites: A.E. 431, 432, 551; Phys. 237.

553. Selected Problems in Nuclear Defense Research (1-6)

ARCHITECTURE (ARCH)

RANIERO CORBELLETTI, *Head of the Department*
308 Sackett Building

Degree Conferred: M.S.

Graduate Faculty: Senior Members Corbelletti, Golany, and Strumillo.

Graduate Faculty: Associate Members Hallock, Inserra, and Vollmer.

Advanced studies are offered in architecture, urban design, and planning. The student is offered opportunity for independent research and extensive interdisciplinary work under the guidance of specialists and scholars in technical, cultural, industrial, and social fields. The nonthesis option is available for the M.S. degree.

For admission, a five-year bachelor's degree program in architecture is required.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

ARCHITECTURE (ARCH)

400. SPECIAL PROJECTS (4-12)
408-409-410. APPLIED ARCHITECTURAL DESIGN (5 each)
441. ARCHITECTURAL DESIGN ANALYSIS (3)
442. ARCHITECTURAL DESIGN ANALYSIS (3)
443. ARCHITECTURAL DESIGN ANALYSIS (3)
461. ARCHITECTURAL STRUCTURAL SYSTEMS I (3)
462. ARCHITECTURAL STRUCTURAL SYSTEMS II (3)
463. ARCHITECTURAL STRUCTURAL SYSTEMS III (3)
464. ARCHITECTURAL SYSTEMS — COMPARATIVE ANALYSIS OF STRUCTURE (1)
465. ARCHITECTURAL BUILDING MATERIALS (3)
471. ENVIRONMENTAL CONTROL SYSTEMS I (3)
472. ENVIRONMENTAL CONTROL SYSTEMS II (3)
475. ARCHITECTURAL SYSTEMS — ENVIRONMENTAL CONTROL (2)
490. ARCHITECTURAL RESEARCH (1-12)

515. NEW TOWNS PLANNING SEMINAR (3) Examination of the process, concepts, and structure of new towns planning as a response to contemporary urban-regional development problems.

516. NEW COMMUNITIES SEMINAR (3) Examination and evaluation of the new communities movement in the United States.

530. ARCHITECTURE I (4-12) Problems in architectural planning and design. Programming and/or implementation methodologies and applications for various environmental design scales.

531. ARCHITECTURE II (4-12) Continuation of Arch. 530 with concentration and specialization options.

532. COMPREHENSIVE PLANNING PROCESS STUDIO (4-12) Field case studies in analysis forecasting and projections of urban physical design elements. Preparation of comprehensive plan, regulations, and implementation.

535. NEW TOWNS PLANNING STUDIO (4-12) A team workshop of planning and design of new towns, involving data gathering, surveys, analysis, projection, and implementation.

591. ARCHITECTURAL RESEARCH (2-12) Guided research project.

ART (ART)

ROBERT H. GRAY, *Head of the Department*
102 Visual Arts Building

Degrees Conferred: M.A., M.F.A.

Graduate Faculty: Senior Member McCoy.

Graduate Faculty: Associate Members Adams, Altman, Cook, DonTigny, Frost, Gray, Shobaken, and Zoretich.

The M.A. program is planned to provide a broad range of experience and study in the visual arts. A thesis in an area of specialization is required. Requirements for admission include a broad undergraduate training in art and the presentation of a portfolio or examples of the student's work.

The M.F.A. program is planned to provide professional emphasis in a specific area of art. A creative project and supporting monograph are required. Requirements for admission include 24 credits in studio art with some indication of concentration in a chosen area and a statement of purpose concerning the professional aims of the candidate. A portfolio, photographs, or examples of the student's work must be presented.

All students accepted for graduate study in art who lack the adequate undergraduate courses or show deficiencies in some area will be required to take additional course work without degree credit.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

ART (ART)

**411. SEMINAR IN CONTEMPORARY ART (3)
*412. INDIVIDUAL INSTRUCTION (1-6)
*425. ADVANCED DRAWING (3)
*430. ADVANCED SCULPTURE (3)
*448. ADVANCED PRINTMAKING (3)
*450. ADVANCED PAINTING (3)
*460. ADVANCED WATERCOLOR (3)
470. GRAPHIC DESIGN II (3)
471. GRAPHIC DESIGN III (3)
472. EXHIBITION CONCEPTS AND STRUCTURE (3)
473. SEMINAR IN DESIGN RESEARCH (3)
*480. ADVANCED CERAMICS (3)
*495. ADVANCED PHOTOGRAPHY (3)

501. ART RESEARCH (2-6) Original study and practice in art relating to material, concept, or technique.

530. ADVANCED SCULPTURE (3-12) Individual projects in sculpture leading to the development of a collection or body of work representative of the artist.

545. PRINTMAKING (2-12) Problems in printmaking leading to the development of a collection or body of work representative of the individual artist.

550. PAINTING (2-12) Individual problems in painting leading to the development of a collection or body of work representative of the artist.

570. DESIGN (2-12) Individual projects in design with special emphasis on professional practice in specialized fields of graphic design.

*May be repeated for a total of 12 credits.
**May be repeated for a total of 6 credits.

580. CERAMICS (2-12) Experimental problems in ceramics leading to the development of a collection or body of work representative of the individual.

ART EDUCATION (A ED)

HARLAN E. HOFFA, *Head of the Department*
269 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Beittel, Edmonston, Hoffa, and Schwartz.

Graduate Faculty: Associate Members Bradley and Chomicky.

This program prepares students for careers in public school art teaching, art supervision, college teaching, administration, or research. To be admitted without deficiencies, the student is expected to have completed either a baccalaureate program in art education or a program leading to certification. Such a program would include work in art studio, art history, art education, education, educational psychology, and psychology. Deficiencies may be made up by course work which is not counted as credit toward an advanced degree.

All students are expected to complete two years of teaching before receiving the doctor's degree. A foreign language is not required of all Ph.D. degree candidates. In lieu of a foreign language, the student will include a series of research and communications studies pertinent to his interests and to his graduate program and may include a foreign language approved by the doctoral committee.

Students with a 2.75 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.75 grade-point average may be made for students with special backgrounds, abilities, and interests. Transcripts should indicate high attainment in appropriate academic and creative work, and recommendations should attest to scholarship and ability to work independently. Creative work, as shown by slides and photographs, should show a high level of involvement and sensitivity to aesthetic forming processes.

Students who seek admission to the graduate program must make formal application to the Admissions Committee of the Department of Art Education.

ART EDUCATION (A ED)

401. STUDIES IN ART MEDIA (1-10)
404. METHODS OF GRAPHICS AND ILLUSTRATIONS (3)
414. ADVANCED CRAFTS FOR TEACHERS (3-6)
420. CERAMICS FOR TEACHERS (3)
434. ART APPRECIATION IN THE EDUCATIONAL PROGRAM (3)
435. ART IN THE ELEMENTARY SCHOOL (3)
436. ART IN THE SECONDARY SCHOOL (3)
486. CURRENT PROBLEMS IN ART EDUCATION (2-3)
487. MURAL PAINTING IN SCHOOLS (3)
488. ADVANCED MURAL PAINTING IN SCHOOLS (3)
489. ART EXPERIENCES WITH CHILDREN (3)
490. INTRODUCTION TO RESEARCH IN ART EDUCATION (3)

501. SEMINAR IN ART EDUCATION (1-6) The analysis of fundamental concepts derived from related disciplines; the examination of current problems; current literature.

504. ADVANCED METHOD IN GRAPHIC PROCESSES (3) Exploration through laboratory experience of printing method: etching, silk screen, linoleum, or other; applications in teaching.

514. Functional Relationships in Crafts (3) Relationships of material design and purpose in crafts discussed by means of outstanding products of different materials, periods, and cultures. Prerequisite: 6 credits in crafts, or 3 in design and 3 in advanced crafts.

516. Analysis of Three-Dimensional Processes in Art (3) Three-dimensional processes analyzed with regard to kinetic, textural, form, and other functions.

520. Advanced Ceramic Art (3) Intensified exploration of throwing, glazing, and firing processes as related to aesthetic considerations in contemporary art forms and past cultures. Prerequisite: A.Ed. 420.

535. Administration and Supervision of Art Education Programs (3) The problems and responsibilities of the city, county, and state art supervisor; curriculum, facilities, financing, supervision, in-service training, and reporting. Prerequisites: A.Ed. 435, 436.

536. Curriculum Development in Art Education (3) Factors affecting art curriculum decisions, analysis, selection, organization, preparation of curriculum. Evaluation and sources of art curriculum improvement and innovation. Prerequisite: 6 credits of methods.

588. History of Art Education (3) Historical development of philosophies in art education in the United States and abroad.

589. Research Methods in Art Education (3-6) Orientation in research methods; findings and designs related to the study of problems in art education.

595. Research in Art Education (1-6) Independent research, under an adviser, to be terminated by a scholarly report proportionately comparable in quality to a master's thesis. Prerequisite: 15 credits in art education on the 400 and 500 levels, including A.Ed. 589.

ART HISTORY (ART H)

HELLMUT W. HAGER, *Head of the Department*
229 Arts II Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Battisti, Cutler, Hager, Hyslop, Mauner, van der Meulen, and Weisman.

Graduate Faculty: Associate Member Kiang.

Graduate work is offered in the following areas: ancient art, medieval and Byzantine art, Renaissance and baroque art, and modern art. Special research opportunities are available through the Center for the Study of Renaissance and Baroque Art.

Candidates for the M.A. degree are required to complete a master's thesis and to demonstrate a reading knowledge of two foreign languages, one of which must be German. The other language is normally French or Italian. Reading knowledge of one of these languages must be demonstrated before the end of four terms of study. These regulations apply equally to Ph.D. students. For those students wishing to enter the doctoral program who have already completed a master's degree from another university, a reading knowledge of one foreign language will be required before the student can be considered for admission to the department.

Candidates with a 3.00 junior-senior grade-point average and a minimum of 21 credits in art history will be considered for admission to the master's program. Lacking these, a promising candidate may be accepted on condition that he make up the deficiency without graduate degree credit. The best-qualified applicants will be accepted up to the number of spaces that are available for new students.

ART HISTORY (ART H)

400. Studies in Art History (3-6 per term)
401. Studies in Greek Art (3)

402. The Illuminated Manuscript (3)
405. Pioneers of Modern Architecture (3-6)
410. Taste and Criticism in Art (3)
411. Art of Imperial Rome (3)
412. The Gothic Cathedral (3)
414. Studies in Italian Baroque Art (3-9)
415. The Skyscraper (3)
416. American Painting: 1876-1913 (3)
422. Studies in Medieval Sculpture (3)
423. Studies in Italian Renaissance Art (3-9)
424. Masters of Northern Baroque Art (3)
425. Movements in Nineteenth-Century Art (3)
432. Problems in Iconology (3)
435. Movements in Twentieth-Century Art (3-6)
450. The History of Photography (3)

510. Studies in Art History (3-6 per term) Original investigation in art history, to be pursued independently or concurrently with course work in particular fields.

511. Seminar in Ancient Art (3-12) Selected topics from the history of Greek and Roman art.

512. Seminar in Medieval Art (3-12) Original research into problems dealing with the art of the Middle Ages.

513. Seminar in Renaissance Art (3-12) Investigations in the area of Renaissance art, centering around major masters and monuments.

514. Seminar in Baroque Art (3-12) Investigations in the area of baroque art centering around major masters and monuments.

515. Seminar in Modern Art (3-12) Lectures, readings, reports, and discussions in the field of modern art.

517. Seminar in Eighteenth-Century Art (3-12) Investigation into themes and problems dealing with eighteenth-century art.

522. Seminar in Byzantine Art (3-12) Specific iconographical and stylistic problems in Byzantine art and its relation to classical antiquity, the medieval West, and Islam.

525. Seminar in Modern Architecture (3-12) Investigation into the works and problems of modern architecture as they relate to the culture of our times.

542. The Illustration of the Apocalypse (3-6) Studies in the illustration of the Apocalypse, iconographical and stylistic, from the early Christian period through Dürer.

555. Art History Field Seminar (3-12) Investigations based on the site study of specific art objects, with trips in successive years to different art centers.

ASTRONOMY (ASTRO)

JOHN P. HAGEN, *Head of the Department*
525 Davey Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Hagen, Matsushima, and Sampson.

Graduate Faculty: Associate Members Bauer, Usher, Winkler, and Zabriskie.

Graduate instruction and research opportunities are available in observational and theoretical radio and optical astronomy, including the sun and objects in the solar system, stellar and planetary atmospheres, variable galaxies, gaseous nebulae, theory of radiative transfer and

atomic collisions, and stellar structure and pulsation theory. Research facilities include two off-campus observatories: (1) Radio Astronomy Observatory, including facilities for optical solar observations near the campus, and (2) an optical observatory near Black Moshannon for spectroscopic and photometric observations. The nonthesis option is available for the M.S. degree.

Modern astronomy has very close ties with mathematics, physics, and engineering. The program required of a doctoral candidate would normally include courses in at least two of these related fields, in addition to those in astronomy. A knowledge of computer programming may be substituted for one of the two foreign languages required.

Applicants with a bachelor's degree in astronomy, physics, mathematics, or electrical engineering are given equal consideration for admission. Opportunity to make up possible undergraduate deficiencies is provided. A grade-point average of 3.00 or better for junior-senior courses in astronomy and related subjects is necessary for consideration for admission, although exceptions to this minimum requirement may be made for students with special backgrounds, abilities, and interests.

ASTRONOMY (ASTRO)

430. General Astronomy for Teachers (3)
460. Fundamentals of Celestial Mechanics (3)
470. Solar Physics (3)
490-491. Introduction to Astrophysics (3 each)
492. (E.E. 492) Space Astronomy and Introduction to Space Science (3)
495. Practical Astronomy (3)

510. Astrophysics (3) An introduction to astrophysics in which the relevant physics, spectra, gas laws, plasmas, and radiation transfer theory are discussed.

511. Astrophysics (3) Stellar atmospheres; considerable emphasis is placed on the sun and on solar-terrestrial relationships. Prerequisite: Astro. 510.

512. Astrophysics (3) Stellar interiors, stellar evolution, pulsating stars, novae and supernovae; some discussion of the interstellar medium and gaseous nebulae. Prerequisite: Astro. 510.

513. Observational Techniques in Astronomy (3) Radiation quantities in theory and as observed. Astrometry, photometry, spectroscopy, stellar classification, interferometric methods. Observational laboratory. Prerequisite: Astro. 511.

516. Nonequilibrium Radiative Transfer Theory (3) Detailed study of theory of radiative transfer when the assumption of local thermodynamic equilibrium is not made, with astrophysical applications. Prerequisite: Astro. 511 or Phys. 561.

520. Galactic Structure (3) Stellar clusters and associations, galactic dynamics, stellar populations, distance determinations, luminosity calibration, and stellar statistics.

523. Observational Theory (3) Information theory of noisy signals, statistics of nonlinear functions, theory and application of convolutions, selection effects, systematic errors, selected problems. Prerequisite: Astro. 513.

524. Celestial Mechanics and Spherical Astronomy (3) Two-body and one-body theory, elliptic motion, expansions, two-body orbit in space, coordinate transformations, planetary equations. Lagrange and Hamilton mechanics. Prerequisites: Math. 452, Phys. 419.

530. Theory of Stellar Atmospheres (3) Theory of photospheric structure, radiative processes, and line-formation in the outer layers of stars, and interpretation of stellar spectra. Prerequisite: Astro. 511.

534. Stellar Structure and Evolution (3) A detailed study of the theory of the interiors and evolution of stars. Prerequisite: Astro. 511 or Phys. 561.

542. Gaseous Nebulae and Interstellar Matter (3) Theory and observations of galactic nebulae and interstellar medium, and problems related to the formation of stars and galactic structure. Prerequisite: Astro. 511.

545. Astrophysical Plasma Kinetic Theory (3) Kinetic theories, fluid behavior, collective phenomena, and collisional processes of plasmas and self-gravitating systems of gas and stars. Prerequisite: Phys. 530.

560-561. General Relativity and Cosmological Models (3 each) Riemannian geometry; general relativity theory and experiments; massive bodies; and Newtonian, Einsteinian, and steady state cosmologies are studied. Prerequisite: Phys. 525.

582. Radio Astronomy (3) Radiometers and antennas; signals in noise; solar physics; quiet and active solar radiation; transfer equation and solar radiation; solar-terrestrial effects. Prerequisite: E.E. 438 or Phys. 467.

583. Radio Astronomy (3) Radio astronomical studies of the moon and planets, galactic and extragalactic sources, and the structure of galaxies using line spectra. Prerequisite: Astro. 582.

596. Individual Studies (1-6)

597. Special Topics (1-6)

BIOCHEMISTRY (BIOCH)

John H. Pazur, *Head of the Department*
108 Althouse Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Clagett, Hartzell, Karakawa, Mallette, McCarl, Pazur, Phillips, R. Schraer, and Shigley.

Graduate Faculty: Associate Members Aronson, Fahnestock, Hammerstedt, Niehaus, Warme, and Winter.

Opportunities for research and graduate study are available in intermediary metabolism, cellular control mechanisms, molecular genetics, enzyme structure, nucleic acids, proteins, carbohydrates, lipids, photosynthesis, and endocrinology.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by a reading knowledge of one foreign language.

Entering graduate students should have had at least one year's work in each of the following: general chemistry, analytical chemistry, organic chemistry, physical chemistry, and general physics. Mathematics through integral calculus is also required. Students with limited deficiencies in these subjects may be admitted but must make up such deficiencies concurrently with their graduate studies. Undergraduate courses in biology, biochemistry, and foreign languages will be helpful to the student but are not required for admission.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

BIOCHEMISTRY (BIOCH)

401. General Biochemistry (3)
402. General Biochemistry (3)
403. Experimental Biochemistry (3)
417. Biochemical Methods (4)
425. Introductory Physical Biochemistry (4)
437. Physiological Biochemistry (3)
438. Physiological Methods (2)
439. Independent Study (1-12)
451. Senior Seminar (1)

501. Enzymes and Biocatalysis (2) Enzyme kinetics, mechanisms of enzymic catalysis, correlation of structure and function, regulation of catalytic activity, literature reports. Prerequisite: Bioch. 402.

503. Biochemical Problems (1-10 per term) Prosecution of an assigned problem under the guidance of an instructor.

507. Seminar in Biochemistry (1 per term)

510. Proteins (2) Biochemical and physical properties of proteins and polypeptides, isolation and purification techniques, sequence analysis, conformational structure. Prerequisite: Bioch. 402.

511. Carbohydrates (2) Stereochemistry, conformational analysis, and chemical reactivity of carbohydrates; biochemistry of monomeric and macromolecular carbohydrates. Prerequisite: Bioch. 402.

512. Lipids (2) The structure, biosynthesis and metabolism of fatty acids, glycerides, phospholipids and sterols. Prerequisite: Bioch. 402.

513. (Bphys. 513) Biochemistry of Nucleic Acids (2) Structure, reactions, synthesis, and biochemical properties of nucleic acids. Prerequisite: Bioch. 402.

515. The Biosynthesis of Macromolecules (2) An enzymological approach to the biosynthesis of DNA, RNA, proteins, complex polysaccharides and membranes. Prerequisite: Bioch. 402.

519. Topics in Metabolism (2) Selected topics dealing with metabolism and metabolic control, literature reports; may be repeated once in successive years. Prerequisite: Bioch. 402.

530. Contemporary Topics in Biochemistry and Molecular Biology (2-4) Lectures and discussions by visiting lecturers on new and significant developments in biochemistry and molecular biology.

BIOENGINEERING (BIOE)

D. B. Geselowitz, *Chairman of the Program Committee in Bioengineering*
328 Hammond Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Adams, Anthony, Brickman, Brighton, Buskirk, Davids, Geselowitz, Jacobs, Kenney, Kline, Lumley, Michael, Munger, Rhoades, Phillips, and Sharma.

Graduate Faculty: Associate Members Arnett, Bishop, Fonash, Hollis, Morrow, Notter, Park, Phillips, Pierce, Ultman, and Weidner.

This is an interdisciplinary program designed to provide the student with graduate-level training in engineering and in the life sciences, and specialized training in specific areas of interaction of engineering with biology and medicine. Graduate instruction in bioengineering is under the direction of a program committee composed of Graduate Faculty representing several departments.

The particular course of study depends on the student's background and area of research specialization. Courses are selected from the life sciences, engineering, and bioengineering. Candidates for the Ph.D. degree generally are expected to complete Phsio. (Biol.) 571-574 plus several additional courses in the life sciences, five courses in bioengineering, and five graduate-level courses in engineering, mathematics, and physics. Supporting courses are available at University Park and The Hershey Medical Center in anatomy, biochemistry, biology, biophysics, dairy science, laboratory animal medicine, physical education, physiology, chemistry, psychology, mathematics, engineering acoustics, material sciences, polymer science, and the engineering departments. Reading knowledge of an acceptable foreign language is required. A thesis is required for the M.S. degree.

Opportunities for specialized research include electrical and mechanical properties of biological materials, development of an artificial heart, hemodynamics, electrocardiography, electroencephalography, applications to nuclear medicine and radiology, biomaterials, lung mechanics, bioinstrumentation, transducers, and neurophysiology of vision.

Students with a degree in engineering, physics, or the life sciences will be eligible for admission. All students must have a strong background in physics and mathematics. This background should include 9 credits in chemistry, including organic chemistry; 9 credits in physics; mathematics through calculus and differential equations; a course in physiology; and a course in linear systems and analysis. Students who lack one or two courses may still be considered for admission, but will have to make up any deficiency early in their graduate program. Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces available. Exceptions to the minimum grade-point average may be made for students with special backgrounds, abilities, and interests.

BIOENGINEERING (BIOE)

401. Introduction to Bioengineering (3)
402. Biomedical Instrumentation and Measurements (3)
425. (Nuc.E. 425) Radiographic Imaging (3)

501. Bioengineering Transport Phenomena (3) Application of the equations of mass, energy, and momentum conservation to physiological phenomena and to the design of artificial organs.

502. Introduction to Bioelectric Phenomena (3) Electric phenomena in nerve and muscle, membrane potentials, Hodgkin-Huxley equations, volume conductor problem, applications to electrocardiography, electroencephalography, plethysmography.

503. Fluid Mechanics of Bioengineering Systems (3) Cardiovascular system and blood flow, non-newtonian fluid description, vessel flows, unsteady flows and wave motion, windkessel theory, transmission line theory.

505. Bioengineering Mechanics (3) Passive and active mechanical properties of tissues, rheological materials, models of muscle contraction, pulmonary mechanics, forces in musculoskeletal system.

BIOLOGICAL CHEMISTRY (BCHEM)

Eugene Davidson, *Head of the Department*
The Milton S. Hershey Medical Center
Hershey, Pa. 17033

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Davidson, Hass, Hill, Miljkovic, and Rosenberg.

Graduate Faculty: Associate Members Roark, Schengrund, and Shiman.

Opportunities for research and graduate study are available in the chemistry and metabolism of complex polysaccharides, cellular differentiation, mechanism of enzymatic reactions, biochemical genetics, biochemistry of complex lipids, conformational analysis of carbohydrates and proteins, natural product chemistry, and physical chemistry of macromolecules.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language. The nonthesis option is available for the M.S. degree.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Interested students should contact the department chairman.

BIOLOGICAL CHEMISTRY (BCHEM)

502. Biological Chemistry (4) Principles of biological chemistry with emphasis on the relationship of macromolecular structure to function in metabolic pathways and specialized tissues.

503. Molecular Genetics (2) Aspects of the mechanism and control of nucleic acid and protein biosynthesis with emphasis on their relationship to genetic phenomena.

504. Biological Chemistry Laboratory (1) Laboratory exercises in biological chemistry related primarily to mammalian systems. Experience with a range of contemporary techniques. Prerequisite or concurrent: B.Chem. 502.

513. Biological Chemistry Macromolecules (3) Physical chemistry of macromolecules; techniques for investigating conformations, size, and interactions. Development and application of thermodynamics to solutions of macromolecules.

523. Metabolism (3) Molecular mechanisms employed by living systems to transform biological compounds, control production and utilization of energy, and regulate metabolic pathways.

540. Seminar (1 per term) Critical discussion of current literature within a facet of biochemistry; experimental design, procedures, and interpretation of results to be emphasized.

551. Kinetics and Mechanism of Enzyme Action (3) Current kinetic theory, rapid reactions, regulatory enzymes, chemical and physical approaches to the study of the mechanism of enzyme action. Prerequisite: B.Chem. 502. Concurrent: B.Chem. 523.

553. Biochemical Techniques (3) Lectures and discussion on approaches to macromolecule separation and characterization, isolation of subcellular organelles and specialized procedures for tissue fractionation. Prerequisite: B.Chem. 502.

590. Research Problems (1-12) Individualized research on biochemical problems conducted by students in departmental laboratories.

597. Special Topics (1-6)

BIOLOGICAL SCIENCE (BI SC)

Anton J. Kovar, *Chairman of the Committee on Biological Science*
121 Buckhout Laboratory

Degrees Conferred: D.Ed., M.Ed.

Graduate Faculty: Senior Members Anthony, Bellis, Butler, Cooper, Dalton, Fergus, Gaffney, Grove, Grun, Hale, Hamilton, Hillson, Hymer, Keener, Kovar, MacCluer, O'Mara, Pursell, Schein, Spackman, Therrien, Traverse, Wickersham, Williams, Witham, and Wright.

Graduate Faculty: Associate Members Abplanalp, Hollis, Mitchell, and Neff.

The M.Ed. program in biological science is designed primarily to meet the needs of secondary school science teachers. The academic degrees M.S. and Ph.D. are not offered in biological science but are available in biochemistry, biology, biophysics, botany, entomology, genetics, microbiology, physiology, plant pathology, and zoology.

The candidate for the M.Ed. degree must earn at least 21 credits in the natural sciences with a minimum of 15 credits in the biological sciences, including at least 6 in the animal sciences

and 6 in the plant sciences. In addition, at least 6 credits in education and a term paper are required. It is suggested that the candidate have at least 2 years of teaching experience before applying to this program.

The D.Ed. program is designed for secondary school and college science teachers. Major course requirements are designated by the candidate's committee with the concept that teachers of biology have a broad background in biological disciplines and related fields. A minimum of 15 credits each is required in professional education and in thesis research. The requirement of a foreign language is at the discretion of the candidate's committee.

In order to enter a program for a higher degree with a major in biological science, the candidate should present 30 credits in the natural sciences, including one year of organic chemistry and one year of physics. A limited number of undergraduate deficiences may be made up in pursuit of the advanced degree. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

BIOLOGY (BIOL)

JOSEPH G. O'MARA, *Head of the Department*
208 Life Sciences I Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Anthony, Bellis, Butler, Cooper, Dalton, Dunson, Fergus, Gaffney, Grove, Grun, Hale, Hamilton, Hibbard, Hillson, Hymer, Keener, Kneebone, Kovar, MacCluer, O'Mara, Pursell, Schein, Spackman, Therrien, Traverse, Wickersham, Williams, Witham, and Wright.

Graduate Faculty: Associate Members Abplanalp, Arnold, Hollis, Mitchell, and Neff.

The department will direct graduate programs in behavior, cell biology, cytology, cytochemistry, environmental science, ultrastructure, and other aspects of modern biology. The courses of study are planned individually by the student and an adviser. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language. Candidates have an option of a thesis or a paper for the M.S. degree.

Admission is restricted to students who have the baccalaureate degree in a biological science and who present a cumulative undergraduate average of at least 3.00. Each applicant must provide scores from the Graduate Record Examination, letters from two persons who are familiar with his academic competence, and a personal statement of his interests and objectives.

BIOLOGY (BIOL)

402. VERTEBRATE NEUROANATOMY (3)
404. PRACTICUM IN EXPERIMENTAL NEUROANATOMY (1-4)
*406. SEMINAR IN NEUROANATOMY (1-6)
407. PLANT ANATOMY (3)
409. BIOLOGY OF AGING (3)
410. GENERAL LIMNOLOGY (3)
411. PLANT BIOLOGY FOR TEACHERS (3)
412. PLANT BIOLOGY FOR TEACHERS (3)
414. ADVANCED SYSTEMATIC BOTANY (3)
417. INVERTEBRATE ZOOLOGY (3)
418. MYCOLOGY (3)
419. GENERAL ECOLOGY (3)
420. (Geol. 420) PALEOBOTANY (3)
421. COMPARATIVE ANATOMY OF VERTEBRATES (4)

*May be repeated for up to 6 credits.

422. Advanced Genetics (3)
423. (Geol. 423) Introductory Palynology (3)
426. Introductory Cytogenetics (3)
427. (Geol. 427) Evolution (3)
428. Population Genetics (3)
430. (Bphys. 430) Molecular Biology of the Gene (3)
431. Comparative Plant Morphology (2)
432. Laboratory in Comparative Plant Morphology (2)
433. Terrestrial Ecology (3)
434. Terrestrial Ecology Laboratory (2)
435. Ecology of Lakes and Streams (3)
436. Laboratory in Freshwater Ecology (2)
437. Histology (4)
440. Embryology (4)
441. Plant Physiology (3)
442. Plant Physiology (3)
443. Plant Physiology (3)
444. Biological Problems (1-6)
445. Phytohormones (3)
448. Ornithology (3)
450. Plant Autecology (3)
451. Plant Synecology (3)
452. Ichthyology (3)
462. (Pty.Sc. 462) Animal Behavior — Ethology (3)
463. (Pty.Sc. 463, Psy. 463) Animal Behavior Laboratory (1-2)
465. General Cytology (3)
466. Laboratory in Cytology (1)
472. Vertebrate Physiology (3)
473. Laboratory in Vertebrate Physiology (2)
475. Cellular Physiology (4)
479. General Endocrinology (3)
480. Marine Biology (4)
481. Aquatic Botany (3)
496. Current Topics in Biology (1-6)

500. Plant Physiology Seminar (1 per term) Selected topics from recent literature; staff and student reports on current research. Spring term, even years.

502. The Physiology of the Fungi (3) Chemical composition, metabolism, toxic and stimulating agencies, spore germination, growth and irritability of the fungi. Fall term, even years.

506. Comparative Anatomy of Vascular Plants (3) Structure of the Tracheophyta from a phylogenetic standpoint. Prerequisite: Biol. 407. Spring term, even years.

511. Advanced Plant Physiology (3) Physiology of plants including uptake of water and minerals, translocations, mineral nutrition, energy relations, respiration and catabolism. Prerequisite: Biol. 442. Fall term.

512. Advanced Plant Physiology (3) Continuation of Biol. 511. Physiology of plants including photosynthesis, synthesis of cellular constituents, growth and development. Prerequisite: Biol. 442. Winter term.

513. Biology Seminar (1 per term) Presentation and discussion of selected topics.

516. Ecological Plant Geography (3) Distribution of plant communities; environmental factors which influence their present distribution; geological-historical development of plant communities, their past distribution. Winter term, odd years.

517. Fish Behavior as Related to Aquatic Ecology (3) Receptor-effector systems, selection of habitat and the effects of behavioral interaction on population levels, growth and survival. Prerequisite: Biol. 452 or 462.

518. Special Problems (1-6) Prosecution of an assigned problem under the guidance of a staff member. Throughout the year as arranged. By appointment.

519. Zoogeography (3) The present distribution of world vertebrates, their evolution, and their patterns of dispersal in the past.

522. Myxomycetes, Phycomycetes, and Ascomycetes (4) Morphology, taxonomy, phylogeny, and life histories; identification and field work. Prerequisite: Biol. 418. Winter term, even years.

523. Basidiomycetes and Fungi Imperfecti (4) Morphology, taxonomy, phylogeny, and life histories. Prerequisite: Biol. 418. Spring term, even years.

524. Seminar in Genetics (1 per term)

531. Bryology (3) Morphology, taxonomy, and ecology of liverworts, hornworts, and mosses; collection, preservation, culturing, and cytologic techniques. Spring term, even years.

533. Problems in Genetics (2-6) Problems to suit needs of individual students; conferences and laboratory work.

535. Morphology of the Tracheophyta Exclusive of Angiosperms (3) Origin, developmental tendencies, structure, and paleobotanical evidence. Winter term, odd years.

536. Morphology of Angiosperms (3) Floral origin and development, fertilization, embryogeny, seeds and fruit development. Prerequisite: Biol. 431.

538. Principles of Microscopic Histochemistry (2) Theoretical basis for the microscopic identification, localization, and quantitative analysis of chemical substances in tissues of organisms. Prerequisite: Biol. 405 or 437.

539. Analytical Histochemistry Laboratory (2-4) Application of histochemical techniques in the microscopic analysis of tissue lipids, proteins, carbohydrates, nucleic acids and proteins. Prerequisite or concurrent: Biol. 538.

540. Phycology (4) Comparative morphology, taxonomy, and ecology of freshwater and marine algae; culturing, collection, preservation techniques.

541. Comparative Physiology (3) Phylogenetic variation in the regulation of the internal environment of animals.

542. (Ent. 542) Systematics (3) Principles and methods of classification, phylogeny and speciation; taxonomic techniques, analysis of species; causal interpretation of animal diversity.

545. Ecosystem Dynamics (3) Analysis of the ecosystem concept based on consideration of ecosystem energetics, components, biotic and abiotic, function, and temporal relations. Prerequisite: Biol. 210.

546. Ecology of Populations and Communities (3) Ecological laws governing population growth and decline; reproductive and mortality rates; predation and composition as limiting factors. Fall term.

550. Neurogenesis (2) Embryonic and evolutionary development of the nervous system. Determination, differentiation, orientation, and specificity of growing and regenerating nerve cells. Prerequisite: Biol. 440.

557. (Sci.Ed. 557) Workshop in the Biological Sciences (3) Projects designed for teachers of biology in the secondary schools. Summer term only.

571. (Phsio. 571) Animal Physiology (2) Physiology of fluid transport mechanisms; examination of the distribution and regulation of body fluids, blood, and hemodynamics. Prerequisite: 3 credits in physiology.

572. (Phsio. 572) Animal Physiology (2) Examination of nutrition, metabolism, and respiration as they relate to subcellular, cellular, and organ organizational levels of the whole animal. Prerequisite: 3 credits in physiology.

573. (Phsio. 573) Animal Physiology (2) Detailed examination of animal reproduction, endocrine secretion and control, neural-muscular activity, central nervous system correlates, and special senses. Prerequisite: 3 credits in physiology.

574. (Phsio. 574) Animal Physiology Laboratory (1-6) Selected problems using advanced physiological techniques to study transport mechanisms, circulation, excretion, respiration, metabolism, and neuroendocrines. Prerequisite: Biol. 473.

582. (Pty.Sc. 582, Psy. 582) Research in Animal Behavior (2-6 per term) Research in special areas of animal behavior involving field or laboratory work.

BIOPHYSICS (BPHYS)

William D. Taylor, *Head of the Department*
618 Life Sciences Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Deering, Ginoza, Keith, Morgan, Person, Rake, H. Schraer, Smyth, Snipes, Strother, Taylor, and Todd.

The major goal of this program is to train students for independent research and teaching in the interdisciplinary areas of biophysics and molecular biology. The students currently in the department have come from a variety of fields including physics, engineering, chemistry, biochemistry, and biology. Graduate students are expected to begin a research program during their first year of study. Personal attention is given each student by a faculty adviser to insure that the student's program is suited to his talents and is one that will permit him to earn a degree in a reasonable time. Course requirements are flexible and depend to a considerable extent on the student's research interests. The master's program is expected to take from 6 to 8 terms (4 terms per year), and the Ph.D. usually requires an additional 8 to 12 terms, including thesis research. Advancement to Ph.D. candidacy is decided on the basis of course and research performance in addition to a written examination. A comprehensive oral examination and thesis defense are integral parts of the Ph.D. program. Knowledge of a foreign language may be required depending on the area of research.

Research interests include theoretical biology, radiation biology, cell biology, molecular biology and genetics, electrophysiology, structure and function of biological membranes, molecular basis of learning and memory, developmental biology, biophysical chemistry, and instrumentation.

BIOPHYSICS (BPHYS)

410. Special Topics (1-6)
419. Drugs and Behavior for Teachers (1-3)
430. (Biol. 430) Molecular Biology of the Gene (3)
473. Introductory Biophysics (3)
474. Molecular Biophysics I (3)
475. Molecular Biophysics II (3)
476. Neurophysiology (3)

501. Seminar in Cell Biology (1) Discussion of current problems and ideas in cell biology with emphasis on reference to recent literature.

513. (Bioch. 513) Biochemistry of Nucleic Acids (2) Structure, reactions, synthesis, and biochemical properties of nucleic acids. Prerequisite: Bioch. 402.

577. Molecular Evolution and Differentiation (3) Evolution and differentiation studied by methods of denaturation and reassociation of DNA, RNA, and amino acid sequences. Current laboratory practice. Prerequisite: Bioch. 41 or 401 or Bphys. 473.

579. PHOTOBIOLOGY (2) Effects of visible and ultraviolet light on biological systems: energy absorption, transfer, utilization; photochemistry; metabolic and genetic responses; repair systems.

580. BIOPHYSICAL SCIENCE (3) Enzyme kinetics; thermodynamics of biological systems; molecular theory of reaction rates; structural aspects of biological reactions. Prerequisite: Bphys. 474 or Chem. 451.

581. RADIATION BIOPHYSICS (2) The action of ionizing radiation and of radioactive decay on biological systems: molecular and cellular aspects. Prerequisite: Bphys. 475.

582. BIOPHYSICS OF NUCLEIC ACIDS (3) Biophysical studies on the structure and function of the nucleic acids, particularly those of bacterial and viral origin.

585. BIOLOGICAL ULTRASTRUCTURE (4) The application of electron microscopy to the study of cell biology. Prerequisite: any of the following — Bphys. 473; Biol. 405, 437; Micrb. 401.

586. BIOLOGICAL MACROMOLECULES (3) Biopolymer characteristics; polymer statistics; size and shape determination; methods of separation; polyelectrolytes; optical and mechanical properties; denaturation; degradation; biosyntheses. Prerequisite: Bphys. 475 or Chem. 451.

587. ULTRACENTRIFUGATION (2) A laboratory course in ultracentrifugation techniques including applications to biophysical problems. Prerequisite: Bphys. 474.

588. PHYSIOLOGY OF NERVES, MUSCLES, AND SENSE ORGANS (2-6) Current literature of the function of nerves, muscles, and receptors. These subjects are considered individually in successive years. Prerequisite: a 400-level course in physiology, biophysics, or physiological psychology.

589. MAMMALIAN CELL CULTURE (3) Recent research in quantitative cell biology as studied with tissues and cells of higher organisms cultured *in vitro*. Prerequisite: Bioch. 401.

590. COLLOQUIUM (1-3)

591. MICROSPECTROPHOTOMETRY (2) Principles of absorption spectroscopy; microspectrophotometer design; determination of cellular constituents using stained and unstained preparations; laboratory exercises. Prerequisite: graduate student standing.

595. ELECTRON SPIN RESONANCE SPECTROSCOPY (3) Experimental and theoretical aspects of electron spin resonance spectroscopy to provide ability for its application to biophysical problems. Prerequisite: basic knowledge of quantum mechanics and electromagnetic waves.

597. SPECIAL TOPICS (1-6)

BOTANY (BOT)

JOSEPH G. O'MARA, *Head of the Department of Biology*
208 Life Sciences I Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Fergus, Grove, Grun, Hamilton, Hillson, Kneebone, Keener, Kovar, O'Mara, Pursell, Schein, Spackman, Therrien, Traverse, Witham, and Wright.

Botanical programs are offered in plant anatomy, cytology, ecology, genetics, morphology, mycology, physiology, and taxonomy. A student having a degree in science or in one of the biological sciences is eligible for admission. Entering graduate students should have had basic courses in chemistry, mathematics, and physics. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Admission is restricted to students who have the baccalaureate degree in a biological science and who present a cumulative undergraduate average of at least 3.00. Each applicant must provide scores from the Graduate Record Examination, letters from two persons who are familiar with his academic competence, and a personal statement of his interests and objectives.

See also Genetics and Physiology.

NOTE: *For courses in Botany and related subjects see Biology.*

BUSINESS ADMINISTRATION (B A)

MAX D. RICHARDS, *In Charge of Graduate Programs in Business Administration*
101 Business Administration Building

Degrees Conferred: Ph.D., M.S., M.B.A.

Graduate Faculty: Senior Members Aggarwal, Beik, Bennett, Bither, Bradley, Carroll, Clewett, Cook, Coyle, Cramer, Ferrara, Fishburn, Greenlaw, Hammond, Hayya, Heitmann, Hellriegel, Hottenstein, Kelley, Koot, Malcom, Mathews, Pashek, Philippatos, Philips, Richards, Rigby, Schrader, Shilling, Slocum, Spychalski, Susman, and Wilson.

Graduate Faculty: Associate Members Basi, Bear, Carey, Carpenter, Curley, Daily, Daniels, Dinkel, Dolich, Evered, Ezzell, Francia, Hrebiniak, Kochenberger, Koehler, Marlow, Melander, Millman, Nelson, Olson, Patterson, Pfaffenberger, Phalan, Pitts, Radebaugh, Twark, Watson, and Williams.

The M.B.A. is a professional program in business administration designed to prepare individuals for managerial positions in business, government, and other nonprofit institutions. Individuals of all undergraduate disciplines — both business and nonbusiness — are encouraged to apply.

The M.B.A. program consists of two distinct portions: (1) 3 credits each in undergraduate accounting, statistics, and economics (not exclusively macroeconomics). These foundation courses may be taken as part of an undergraduate curriculum or at the University prior to starting graduate-level studies; (2) 45 credits of graduate courses and a professional paper.

Graduate-level work on the M.B.A. may be started fall term only. The time required to complete the graduate program, based on full-time study, is fifteen months. The M.B.A. student body is divided into diverse sections of approximately forty students, with each section proceeding through the same core classes. Emphasis is placed on student interaction and shared learning both inside and outside the classroom.

The M.S. and Ph.D. programs with a major in business administration are designed for those interested primarily in research and teaching. The communication and foreign language requirement for the Ph.D. degree may be satisfied by a reading knowledge of two foreign languages or a reading, listening, and speaking knowledge of one language. The candidate may substitute quantitative analysis and/or behavioral science for the required reading knowledge in one or two languages.

For admission to the M.S. program, approximately 30 acceptable undergraduate credits in business administration, economics, and mathematics are required. An applicant may be admitted without foundation courses to be made up without degree credit. A student has an option of a thesis or a paper for the M.S. degree.

Applicants are evaluated for admission on the basis of academic potential and other factors giving evidence of high probability of completing the program. Data useful for evaluating academic potential include the applicant's professional and academic accomplishments, ATGSB scores, and recommendations. The best-qualified applicants will be accepted up to the number of spaces that are available for new students.

Applicants to any of the graduate programs in business administration are required to take the Admission Test for Graduate Study in Business (ATGSB) given by the Educational Testing Service. Candidates are strongly urged to take the test at the earliest possible date. It is given at University Park and at numerous locations in most states and foreign countries in November, January, March, and July. For dates and locations, see the *Bulletin of Information,* Admission Test for Graduate Study in Business, Educational Testing Service, Princeton, N.J. Applicants should read the bulletin carefully. All arrangements for taking the test are made directly with the Educational Testing Service.

This graduate program is accredited by the American Association of Collegiate Schools of Business.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 230).

ACCOUNTING (ACCTG)

401. Advanced Accounting (3)
403. Auditing (3)
404. Managerial Accounting (3)
406. Advanced Federal Tax Accounting (3)
409. Machine and Electronic Accounting Methods (3)

*398G. Accelerated Elementary Accounting (3) The theory and technique of financial and managerial accounting: preparation, analysis, and interpretation of financial statements. Open to graduate students only.

503. Seminar in Auditing (3) The attest function of independent public accountants, verification of financial statements; problems of evidence, independence, ethics, professional responsibilities. Prerequisite: Acctg. 403.

504. Seminar in Managerial Accounting (3-6) Accounting and the managerial processes of planning, control, and decision making.

507. Seminar in Financial Accounting (3) Theoretical basis of financial accounting.

508. Contemporary Issues in Accounting (3) Selected problems of current interest to the accounting profession.

511. Financial and Managerial Accounting (3) Fundamental financial and managerial accounting concepts and issues from the viewpoint of the report user.

512. Financial Accounting Theory and Reporting Problems (3) Measurement and reporting of financial information for external purposes, with particular attention to current problems in asset and income measurement. Prerequisite: Acctg. 511.

515. Development of Accounting Thought (3) Development of accounting thought from ancient civilizations to the present.

590. Colloquium (1-3)

596. Individual Studies (1-6)

597. Special Topics (1-6)

BUSINESS ADMINISTRATION (B A)

499. Foreign Study in Business Administration (2-6)

503. Seminar in Public Utilities (3)

537. (Cmp.Sc. 537) Management Information Systems Design (3) Cost, value, and technical considerations in analysis and design of information systems whose purposes are to aid decision making in organizations.

538. Information Systems for Planning and Control (3) Analysis of information requirements for planning, decision making and performance measurement in organizations.

539. Seminar in Management Information Systems (3) Special topics selected from contemporary issues in management information systems.

540. Business Administration Theory and Practice (3) An integrating course primarily for M.S. students using cases requiring analysis involving interrelated aspects of business administration and control.

541. Readings in Business Administration (6) Critical study and discussion of important topics in business administration.

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*No graduate credit is given for this course.

550. Behavioral Science in Business (3) Application of behavioral science concepts and analytical methods to problems in business organizations. Analysis of administrative behavior and decision making.

555. Business and Society (3) Evolution of the business organization and the changing framework of its operations, responsibilities, and social control.

574. Business Research (1-3) A project paper, comparable in quality and scope of work to a graduate thesis, on problems of a company. Prerequisite: 15 credits of 400- and 500-level courses in business administration.

577. Administrative Integration (3) An analysis of coordination of the functional areas of business in relation to overall company objectives. Prerequisite: 15 credits of 400- and 500-level courses in business administration.

BUSINESS LAW (B LAW)

400. Real Estate Law (3)

*398G. Accelerated Business Law (3) Social control through law: courts; policies underlying individual rights; negotiable and nonnegotiable contractual rights in society. Open to graduate students only.

BUSINESS LOGISTICS (B LOG)

412. Transport Planning Analysis (3)
420. Urban Transportation (3)
430. Transport Problems (3)
440. Logistics Systems Analysis (3)

538. Logistics Systems Management (3) Control of the movement of goods; coordination of supply and demand in creation and maximization of time and place utility.

540. Transport Policy (3) Role of transport in the economy. Transport systems elements, development, cost and pricing characteristics. Public control and public policies.

541. Socioeconomic Analysis in Transportation (3) Role of transport in social and economic activity. Planning and coordination of transport systems. Designed for the Traffic Engineering program.

565. Seminar in Business Logistics (3-6)

590. Colloquium (1-3)

596. Individual Studies (1-6)

597. Special Topics (1-6)

FINANCE (FIN)

405. Capital Budgeting (3)
406. Security Analysis and Portfolio Management (3)
408. Financial Markets (3)
410. Speculative Markets (3)

*398G. Accelerated Financial Management (3) Financial planning and forecasting; management of working capital, capital budgeting, and dividend policy; capital structure and valuation. Open to graduate students only.

504. Problems in Finance (3-6) Planned individual projects involving library, laboratory, or field work.

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*No graduate credit is given for this course.

506. Portfolio Theory and Policy (3) Rigorous examination and analysis of asset-holder behavior under conditions of risk and uncertainty.

508. Analysis of Financial Markets (3) Analysis of factors affecting price determination in financial markets.

510. Contemporary Issues in Financial Institutions (3) Critical investigation of problems of current interest in the market structure and internal operations of financial institutions.

531. Financial Management (3) An intensive examination of techniques available to aid the financial manager in decision making.

532. Normative Models in Business Finance (3) Application of advanced analytical techniques and models to financial decision making under uncertainty.

541. Financial Theory (3) A theoretical analysis of the elements of finance.

561. Seminar in Finance (3-6) Comparative analysis of research in the theories of finance; relationships to business management practices.

INSURANCE (INS)

400. Estate Planning (3)

500. Insurance Theory and Practice (3) Insurance as an institution, a technique, a legal contract; its environment as a regulated industry.

504. Problems in Insurance (3) Planned individual projects involving library, laboratory, or field work.

510. Risk Management (3) Analysis of managerial problems and responsibility of risk analysis, removal or reduction, and allocation of corporate resources to provide indemnity.

520. Seminar in Insurance (3-6) Selected topics on advanced aspects of risk management with emphasis on the insurance technique for treating hazards.

INTERNATIONAL BUSINESS (I B)

501. The International Environment (3) Conceptual approach analyzing and predicting influences of social, political, and economic norms and values upon diverse societies' managerial decision making.

502. International Business Macro Theory and Policy I (3) International economic trade and monetary tools are applied to current national policy issues to determine effects on international business operations. Prerequisite: Econ. 333.

503. International Business Micro Theory and Policy I (3) Analysis of the internal operations of multinational firms; design of optimal strategies of operation under varying environmental conditions.

504. Seminar in International Business (3-6) Seminar in techniques applied to selected topics; market structures; capital budgeting, investment; comparisons of foreign norms and values; multinational organization characteristics.

590. Colloquium (1-3)

596. Individual Studies (1-6)

597. Special Topics (1-6)

MANAGEMENT (MGMT)

410. Operations Planning and Control (3)
420. Management of Personnel Systems (3)
422. Advanced Organization Theory (3)
430. Administrative Management (3)
432. Simulation of Management Systems (3)
435. Cases in Public Relations (3)

*398G. ACCELERATED BUSINESS MANAGEMENT (3) The concepts of management and its decision processes including special attention to operations management.

510. OPERATIONS MANAGEMENT (3) Integration and application of decision making to operational and policy problems within the business firm.

515. DESIGN OF OPERATION OUTPUT SYSTEMS (3) Examination of research-based findings in operations management with a focus on the design and reliability of production systems.

516. OPERATIONS PLANNING AND CONTROL (3) Examination of research-based findings in operations management. The focus is on the operation and control of production systems.

517. CONCEPTUAL BASES OF SOCIOTECHNICAL SYSTEMS (3) Integrates behavioral science and operations management in sociotechnical framework. Design of sociotechnical systems.

518. MANAGEMENT OF INVENTORY SYSTEMS (3) Analysis of business organizations as integrated inventory systems. Inventory theory and model building as tools for management decision making. Prerequisite: Q.B.A. 561 or Mgmt. 510 or I.E. 509.

519. SEMINAR IN OPERATIONS MANAGEMENT (3-6)

520. ORGANIZATION THEORY (3) Theoretical and operating structures in formal business organizations; relation of formal organization to informal groups and to individuals.

521. SEMINAR IN ORGANIZATIONAL BEHAVIOR (3) Examination of research-based findings on organizational behavior. Methodological techniques for studying human behavior in formal organizations.

523. ORGANIZATIONAL CHANGE: THEORY AND PRACTICE (3) Analysis of research, theory and practice in dynamics of organizational change. Research literature reviewed for evaluation of concepts and methods.

524. INTERPERSONAL RELATIONS IN ORGANIZATIONS (3) Development of skills and sensitivity for dealing with interpersonal relationships in complex organizations. Prerequisite: B.A. 550.

531. MANAGEMENT INFORMATION SYSTEMS (3) Information system theories and methods applied to administrative structures and management decisions in organizations.

540. PERSONNEL MANAGEMENT (3) Theoretical constructs underlying personnel administration; analysis of professional personnel functions in business firms.

570. SEMINAR IN MANAGEMENT (3-6) Comparative analysis of research in the theories of the administrative sciences; relationships to business management practices.

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

MARKETING (MKTG)

424. MARKETING RESEARCH PROJECTS (3)
430. SELECTED TOPICS IN CONSUMER BEHAVIOR (3)
435. MARKETING AND PUBLIC POLICY (3)

*398G. ACCELERATED MARKETING MANAGEMENT (3) Analyses of customer and market behavior, marketing systems, and competitive strategies; programming product, pricing, distribution, and promotion. Open to graduate students only.

500. MARKETING MANAGEMENT (3) Analysis of management's marketing problems including market analyses, pricing, channel of distribution, promotion, competition, product strategies, and marketing research.

510. PLANNING MARKET STRATEGY AND PROGRAMS (3) Development of marketing strategy for the firm and design of integrated product-service, promotion, and distribution programs utilizing systems analysis.

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*No graduate credit is given for this course.

520. Quantitative Analysis for Marketing Decisions (3) Sales forecasting, new product proposals, media selection, and market testing analyzed using statistical and decision theory and other mathematical techniques.

530. Consumer and Market Behavior (3) Buying behavior: concepts from the behavioral sciences, including utility, culture, life cycle, personality, attitudes, and learning.

540. Marketing and Society (3) Marketing problems of society, domestic and regional marketing systems; governmental policies toward marketing; social performance of marketing.

544. Marketing Theory (3) The development of marketing concepts, behavioral and other marketing theories; public policy and the role of marketing in societies.

596. Individual Studies (1-6)

597. Special Topics (1-6)

QUANTITATIVE BUSINESS ANALYSIS (Q B A)

403. Intermediate Business Statistics (3)
404. Sampling in Business Operations and Research (3)
451. Analytical Methods in Business (3)
452. Analytical Methods in Business (3)
461. Probabilistic Models in Business (3)
490. Special Topics (1-6)

*398G. Accelerated Business Statistics (3) Basic characteristics of univariate and bivariate distributions, probability theory, introduction to estimation, tests of hypotheses, and time series analysis. Open to graduate students only.

500. Seminar in Business Statistics (3-6)

501. Advanced Business Statistics (3)

510. Statistics in Business Research (3) Statistical principles and procedures essential to the interpretation and performance of research in business administration. Prerequisite: common requirements of M.B.A. program.

521. Quantitative Analysis for Business Decisions (3) Construction and use of quantitative models in business decision making. Prerequisite: common requirements of M.B.A. program.

527. Statistical Decision Theory (3) A systematic survey and analysis of the concepts and methods of Bayesian statistical decision theory.

532. Management Systems Simulation (3) Application of computer simulation to the analysis and design of management decision systems. Design of simulation experiments in business research. Prerequisite: 3 credits of computer programming.

550. Seminar in Mathematical Programming (3-6) Intensive treatment of theory and computational algorithms of mathematical programming; emphasis on operational application to complex management and business problems. Prerequisite: I.E. 510.

561. Stochastic Models for Management Decisions (3) Introduction to stochastic processes in business organizations. Application of stochastic models to the conceptualization, analysis, and solution of management problems. Prerequisite: Math. (Stat.) 427.

570. Management Science: Implementation and Control (3) Development and application of management science models. Model formulation and specification, sensitivity analysis, problems encountered in implementation and control.

590. Colloquium (1-3)

596. Individual Studies (1-6)

597. Special Topics (1-6)

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*No graduate credit is given for this course.

REAL ESTATE (R EST)

400. Urban Land Utilization (3)

CERAMIC SCIENCE (CERSC)

Guy E. Rindone, *In Charge of Graduate Programs in Ceramic Science*
201 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Bradt, Hummel, McKinstry, Newnham, Rindone, Stubican, and Williamson.

Graduate Faculty: Associate Members Biggers, Spear, and Tressler.

This program is one of the options in which a graduate student in the Department of Material Sciences can receive an advanced degree. In view of the wide field covered by ceramic science, the graduate courses may be selected with a bias toward physical ceramics, chemical ceramics, or glass science.

The communication and foreign language requirement may be satisfied by (1) examinations in two languages — French examination administered by the ceramic science faculty and a second language examination by the appropriate language department or (2) examination in one foreign language *and* either 6 credits of computer science or 6 credits of statistics, or 3 credits of computer science and 3 credits of statistics.

Special facilities exist for research in the areas of electroceramics, rheology, phase equilibria, solid state synthesis, mechanical properties, ferrite and ferroelectric studies, glass science, and high temperature reaction kinetics. Suitable preparation for graduate study in this program may be found in one of the material sciences such as ceramics or metallurgy, in engineering fields such as chemical or mechanical engineering, in the basic physical sciences, or in the earth sciences.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

CERAMIC SCIENCE (CERSC)

400. (Min. 400) Nonmetallic Crystal Chemistry (2-3) *Mr. Newnham*
402. Principles of Ceramic Engineering (3) *Mr. Williamson*
404. Ceramic Seminar (1) *Mr. Hummel*
405. Ceramic Research and Design (1)
406. Rheology and Fluid Properties of Ceramic Systems (2) *Mr. Williamson*
407. Ceramic Materials Laboratory (2) *Mr. Williamson*
408. Heat Treatment of Ceramic Materials (1) *Mr. Tressler*
409. Heat Treatment Laboratory (2) *Mr. Tressler*
410. Phase Relations in Ceramic Systems (3) *Mr. Hummel*
411. Principles of Ceramic Processes (2) *Mr. Stubican*
414. Mechanical Properties of Ceramics (3) *Mr. Bradt*
415. Principles of Glass Technology (3-4) *Mr. Rindone*
420. Refractories (2-3) *Mr. Stubican*
425. Ceramic Research and Design (2)
430. Electroceramics (2) *Mr. Biggers*
431. Electroceramics Laboratory (1) *Mr. Biggers*

500. SEMINAR IN CERAMIC SCIENCE (1-2 per term) Current developments in ceramic science and related fields. Required of all graduate students in ceramic science. *Staff*

501. SURFACE BEHAVIOR OF CERAMIC MATERIALS (2-4) Surface chemistry of ceramics. Rheology of ceramic powders, suspensions and pastes. *Mr. Williamson*

503. USE OF PHASE EQUILIBRIA DATA IN CERAMIC SCIENCE (2-5) Phase equilibria in unary, binary, ternary, and other systems; applications in product development and in understanding behavior of ceramic materials. *Mr. Hummel*

504. SOLID STATE REACTIONS IN CERAMIC SYSTEMS (2) Thermodynamic, kinetic, and structural study of reactions and of equilibrium in ceramic systems. Prerequisites: Chem. 451, 452. *Mr. Stubican*

505. PHASE TRANSITION IN SOLIDS (2) Phase transitions will be studied in detail with respect to the crystal structure, free energy, and physical properties. *Mr. McKinstry*

506. MECHANICAL PROPERTIES OF CERAMICS (3) Theoretical consideration of internal stresses, dislocations and dislocation processes, and macro- and microstructural variables on the mechanical properties of ceramics. Prerequisite: Cer.Sc. 414. *Mr. Bradt*

507. THERMAL PROPERTIES OF CERAMIC MATERIALS (2-3) Heat capacity, heat of fusion, thermal conductivity, and thermal expansion in relation to macroscopic measurements and basic atomic concepts applied to ceramic materials. *Mr. Stubican*

508. DIELECTRIC AND MAGNETIC PROPERTIES OF CERAMIC MATERIALS (2-3) Preparation and properties of ceramic semiconductors, dielectrics, and magnetic materials. *Mr. Newnham*

509. COMPOSITE MATERIALS (3) Manufacturing processes, atomic and molecular background, and topological relationships of macro- and microstructure to the physical properties of composites. *Messrs. Bradt and Tressler*

510. SEMINAR IN GLASS TECHNOLOGY (1-2 per term) Current developments in glass technology and related fields. *Mr. Rindone*

511. THE CONSTITUTION OF GLASS (2-3 per term) Historical and current concepts of the atomic structure of glass; relationship of structure to chemical and physical properties. *Mr. Rindone*

512. SELECTED PROPERTIES OF THE VITREOUS STATE (2-3 per term) Measurement and interpretation of such properties as: radiation effects; viscoelasticity; electrical, mechanical, optical, and thermal properties. *Mr. Rindone*

515. SPECIAL PROBLEMS IN CERAMIC SCIENCE (1-6 per term) Advanced individual study on a problem in ceramics.

516. SELECTED TOPICS IN CERAMIC SCIENCE (1-3 per term) Intensive group study of special topics.

530. (Min. 530) STRUCTURE, PROPERTIES, AND OCCURRENCE OF CLAY MINERALS (2-5) Structure analysis and identification of clay minerals; mineral transformation and behavior; occurrence, genesis, and petrography of fine-grained sediments.

NOTE: *Courses in the use of X-ray diffraction, electron microscopy, and the electron microprobe in ceramic science studies are listed under Materials Science.*

CHEMICAL ENGINEERING (CH E)

LEE C. EAGLETON, *Head of the Department*
160 Merrell R. Fenske Laboratory

Degrees Conferred: Ph.D., M.S., M. Eng.

Graduate Faculty: Senior Members Braun, Danner, Daubert, Eagleton, Engel, Jones, Kabel, Klaus, and McCormick.

Graduate Faculty: Associate Members Barton, Duda, Notter, Radke, and Ultman.

Course offerings or research facilities are available in the following areas: phase equilibria, thermodynamics, kinetics, mass transfer, transport phenomena, unit operations, unit processes, bioengineering, applied chemistry and petrochemistry, petroleum technology, rheology, and lubrication. A foreign language is not required for the Ph.D. degree.

To be admitted, a student should be a graduate of an accredited major in chemical engineering or the equivalent. Graduates of other accredited engineering or physical science majors may be admitted but will be required to make up certain undergraduate deficiencies without graduate credit. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. Applicants attending foreign universities are required to submit Graduate Record Examination scores. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

CHEMICAL ENGINEERING (CH E)

401. CHEMICAL PROCESS ENGINEERING (4)
404. CHEMICAL ENGINEERING ECONOMICS (3)
406. CHEMICAL ENGINEERING PROBLEMS (3)
408. CHEMICAL ENGINEERING LABORATORY II (2)
413. MASS TRANSFER OPERATIONS (3)
414. KINETICS AND INDUSTRIAL CHEMISTRY (4)
415. MATHEMATICAL MODELING IN CHEMICAL ENGINEERING (3)
416. TECHNIQUES OF PROCESS DESIGN (3)
420. CRYOGENIC ENGINEERING (3)
422. MODERN PETROLEUM TECHNOLOGY — PROCESSES AND PRODUCTS (3)
430. NUCLEAR CHEMICAL ENGINEERING (3)
431. ADVANCED INDUSTRIAL CHEMISTRY APPLICATIONS (3)
435. CHEMICAL REACTION KINETICS (2)
440. CHEMICAL ENGINEERING MATERIALS (3)
445. PROJECTS IN CHEMICAL ENGINEERING (1-6)
446. INTRODUCTION TO TRANSPORT PHENOMENA (3)
448. ADVANCED MASS TRANSFER OPERATIONS (3)
450. PROCESS DYNAMICS (3)
453. THERMODYNAMICS FOR CHEMICAL ENGINEERS (3)
455. CHEMICAL REACTOR DESIGN (3)
460. CHEMICAL ENGINEERING (4)

500. SEMINAR IN CHEMICAL ENGINEERING (1) Required of all graduate students.

507. SIMULATION AND MODELING (3) Synthesis of subsystem and system models emphasizing the generality of the principles for application to diverse physical and chemical processes.

508. PRINCIPLES OF INDUSTRIAL ORGANIC CHEMISTRY (3) Principles and practices of modern conversion processes in the manufacture of organic chemicals. Prerequisites: Chem. 31, 452. *Mr. Jones*

509. Heat Transfer Applications (3) Advanced treatment of steady-state and transient conduction, convection, and radiation, with emphasis on numerical methods and design techniques. Prerequisite: an undergraduate course in heat transfer. *Mr. Daubert*

516. Methods of Process Design (3) Survey of mathematical techniques of chemical process design with emphasis on economic choice and optimal decision making. *Mr. Engel*

524. Chemical Engineering, Application of Thermodynamics (3) Elements of thermochemistry and thermodynamics of greatest importance in chemical engineering.

535. Chemical Reaction Engineering (3) Optimal design of batch and continuous chemical reactors and reactor batteries; effect of mixing on reactor operation. Prerequisite: Ch.E. 435.

545. Transport Phenomena I (3) Momentum, heat, and mass transfer, steady and unsteady state, laminar and turbulent flow, coupling, analogies, chemical engineering applications.

546. Transport Phenomena II (3) Momentum, heat, and mass transfer, steady and unsteady state, laminar and turbulent flow, coupling, analogies, chemical engineering applications.

548. Multistage Mass Transfer Operations (3) Rigorous solution of complex problems in distillation, extraction, and absorption including computer methods. Prerequisite: an undergraduate course in mass transfer. *Mr. Barton*

597. Special Topics (1-6)

CHEMISTRY (CHEM)

Joseph A. Dixon, *Head of the Department*
152 Davey Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Allcock, Ascah, Benkovic, Bernheim, Deno, Dixon, Fritz, Gold, Haas, Hamilton, Hayes, Heicklen, Hisatsune, Horrocks, Jackman, Jordan, Jurs, Lampe, Lowe, Miller, Olofson, Richey, Rosenblatt, Shamma, Skell, Steele, Wartik, and Zook.

Graduate Faculty: Associate Members Crawford, Goncalves, Hendry, Lotz, Riehl, Risby, and Villafranca.

The Ph.D. program in chemistry provides students with a broad background in one of the areas of chemistry (analytical, biological, inorganic, organic, or physical) and intensive research experience culminating in the preparation of a formal thesis. The goal of the program is to prepare students for a variety of careers in academia, government, or industry. The general facilities are excellent, and the computer, cryogenic, radiochemical, and spectroscopy laboratories provide unusual research opportunities. Distinguished visiting scholars conduct informal discussions each Thursday at a departmental colloquium.

The department requires a knowledge of French, German, Japanese, or Russian as a condition for awarding either the M.S. or Ph.D. degree. Candidates who have taken and passed two undergraduate courses in French, German, Japanese, or Russian will be certified as having completed the communication and foreign language requirement. For the M.S. degree the student has the option of writing a thesis or a paper.

For admission, at least integral calculus plus one year's work in general physics, organic chemistry, physical chemistry, and either analytical or inorganic chemistry is normally required. Students who have appropriate course backgrounds and who present a 2.50 average in all undergraduate courses in chemistry, physics, and mathematics will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Prior to scheduling their first term programs, new students will take examinations in the areas of analytical, inorganic, organic, and physical chemistry. The information obtained from these tests will assist both the student and his adviser in making up a program best suited to the

student's needs. These examinations are normally given just prior to the regular registration period.

CHEMISTRY (CHEM)

400. Chemical Literature (1)
401. Seminar (1)
402. Chemistry of the Environment (3)
405. Nuclear and Radiochemistry (3)
408. (Cmp.Sc. 408) Computer Applications in Chemistry (3)
410. Inorganic Chemistry (2)
411. Advanced Inorganic Chemistry (2)
423. Advanced Analytical Chemistry (3)
424. Advanced Analytical Laboratory (2)
426. Chemical Instrumentation (3)
431. Organic and Inorganic Preparations (3)
435. Advanced Organic Chemistry Laboratory (3)
439. Structural Analysis of Organic Compounds (3)
448. Surface Chemistry (2)
*451-452. Physical Chemistry (3 each)
453. Advanced Physical Chemistry (3)
454. Advanced Physical Chemistry (3)
455. Physical Chemistry of High Polymers (3)
*457. Experimental Physical Chemistry (1-2)
*458. Experimental Physical Chemistry (1-2)
489. Introduction to Chemical Research (1-10)
493. Selected Topics in Chemistry for Teachers (3-9)

500. Seminar in Chemistry (1 per term)

516-517. Inorganic Chemistry (3 each) Systematic treatment of inorganic chemistry in terms of modern concepts.

518. Special Topics in Inorganic Chemistry (3 per term) Modern developments in specialized fields.

525. Analytical Processes (3) Theoretical foundations and contemporary developments.

526. Modern Instrumental Analysis (3)

527. Special Topics in Analytical Chemistry (2-12)

531. Special Topics in Organic Chemistry (3-12) Prerequisite: Chem. 536.

534. Chemical Applications of Quantum Theory (3) A development of Molecular Orbital Theory up to the level of present-day usage in organic and inorganic chemistry.

535-536. Organic Reaction Mechanisms I and II (3 each) Reaction mechanisms and their determination by kinetic and nonkinetic methods. Reactive intermediates. Prerequisite: Chem. 439.

537. Synthesis in Organic Chemistry (3) Theory and methods of directed syntheses, including stereospecific and stereoselective schemes; biologically inspired syntheses. Prerequisite: Chem. 536.

544. Chemical Thermodynamics (3) Development of thermodynamic theory with special reference to common physical changes and chemical reactions. Prerequisite: Chem. 452.

545. Statistical Thermodynamics (3) The calculation of thermodynamic properties from molecular and spectroscopic data. Prerequisites: Chem. 453 or 544, and Chem. 565.

560. Topics in Physical Chemistry (2-6)

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*Graduate credit not allowed for students majoring in chemistry or chemical engineering.

563. CHEMICAL KINETICS (3) Theory and measurement of the rates of chemical reactions, molecular dynamics, and mechanisms of chemical reactions. Prerequisites: Chem. 453 or 544, and Chem. 565.

565. ATOMIC AND MOLECULAR STRUCTURE (3) Introduction to modern theoretical chemistry, spectroscopy, and structure of atoms and molecules.

566. QUANTUM CHEMISTRY (3) Theoretical calculations of electronic properties of atoms and molecules. Prerequisite: Chem. 565.

567. QUANTUM CHEMISTRY (3) A continuation of Chem. 566, including problems and theories of electron correlation. Prerequisite: Chem. 566.

571. POLYMER CHEMISTRY (3) The synthesis, reactions, and structure determination of high polymers.

589. STUDIES IN CHEMISTRY (1-9) Theoretical research, experimental research, or a critical survey of the literature in an area of chemistry.

CIVIL ENGINEERING (C E)

RAYMOND E. UNTRAUER, *Head of the Department*
212 Sackett Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Aron, Barnoff, Cady, Gotolski, Larson, McDonnell, Nesbitt, Reich, Taylor, Untrauer, and Unz.

Graduate Faculty: Associate Members Davinroy, Long, McClure, Miller, Mozingo, Reed, Regan, Weeden, West, and Willenbrock.

Students may specialize in structures, hydraulics, hydrology, transportation engineering, traffic engineering, materials, construction, soils, and sanitary engineering, or combinations of these. Relevant courses are offered both by the Department of Civil Engineering and by other departments of the University.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by a reading knowledge of an acceptable foreign language and proficiency in English. A thesis is required for the M.S. degree. An engineering report is required for the M.Eng. degree.

Candidates normally should be graduates in engineering from an accredited college of engineering. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 230).

See also Sanitary Engineering.

CIVIL ENGINEERING (C E)

400. SEMINAR (1-3)
401. CIVIL ENGINEERING PROJECTS (2-12)
421. HIGHWAY ENGINEERING (3)
422. TRANSPORTATION ENGINEERING (3)
423. TRAFFIC CHARACTERISTICS AND MEASUREMENTS (3)
424. CIVIL ENGINEERING MATERIALS (3)
431. CIVIL ENGINEERING CONSTRUCTION (3)
446. ADVANCED SOIL MECHANICS (3)
447. STRUCTURAL ANALYSIS BY MATRIX METHODS (3)
448. ADVANCED STRUCTURAL DESIGN (3)

451. Advanced Hydrology (3)
452. Water Resources and Computations (4)
462. Open Channel Hydraulics (3)
465. River and Waterways Engineering (3)
471. Environmental Sanitation (3)
472. Water Pollution Control (3)
476. Solid Waste Management (3)

500. Seminar in Civil Engineering (1-6) Reports on research and special topics. Course may be continued in subsequent terms.

501. Civil Engineering Projects (3-10) Investigation or design projects in structures, transportation, hydraulics, or civil engineering materials.

511. Engineering Soil Characteristics (3) Physical and chemical factors in soil which influence their engineering properties of strength, deformation, permeability, and soil stabilization.

512. Applied Soil Mechanics (2-5) Soil classification by type of clay minerals and profile development; aerial photographic interpretation of soils and applications to site selection for dams, highways, and airports.

513. Soil Exploration and Analysis (3) Laboratory evaluation of parameters used in modern soil mechanics. Involved techniques of soil testing, test limitations, sampling influences, technical reports.

519. Traffic Administration and Finance (2) Organization and administration of traffic engineering at various levels of government; leaders in the highway transportation field are guest lecturers.

520. Pavement Design (3) Fundamental principles; properties of pavement components; design tests; design of flexible pavements; design of rigid pavements; pavement evaluation and strengthening.

521. Techniques of Transportation Analysis (2-4) Transportation functions, travel patterns, basic analytical methods in the planning content.

522. Highway Operations (2) Theory and application of traffic controls, including functional operations of traffic signals, systems, and networks; the design of highway lighting.

523. Urban Transportation Planning, Technology, Policy, and Administration (2-4) Characteristics of urban areas, the urban transportation planning process, present and future urban transportation systems, urban transportation policy and administration.

524. Advanced Problems in Civil Engineering Materials (2-6) Study, in the literature and by laboratory investigation, of selected topics on field-controlled civil engineering materials. Prerequisite: C.E. 424.

525. Airport Planning and Design (3) Aircraft characteristics; aeronautical demand; site selection; airport configuration; capacity analysis; design of landing and terminal areas.

526. Transportation Design-Impacts Interaction (3) Transportation facilities with specific consideration of impact of such facilities on nontransport considerations; interaction of design criteria and impacts.

527. Theory of Traffic Flow (3) Phenomenon of vehicular traffic flow; flow density relationships; spacing; gap counting; delays; problems involving interrupted flow; multiflow routes.

528. Queuing Models in Transportation (3) Arrival patterns; the service mechanism, queue discipline; delays; busy period; queue length. Applications to pedestrian and vehicle delay. Prerequisite: Stat. 418.

529. Highway Geometric Design (3) Principles of road and parking terminal design with emphasis on operations; highway planning related to alternate solutions of design problems. Prerequisites: C.E. 423, 522.

533. Ultimate and Plastic Design Methods (3) Plastic design of steel structures. Limit design of concrete structures. Ultimate theories applied to plate and slab problems.

537. Matrix Method of Structural Analysis (3) Analysis of structures using advanced matrix techniques, transformation of matrices, energy concepts, iterative solutions, applications to linear and nonlinear structures. Prerequisite: C.E. 447.

539. Approximate Methods of Structural Analysis (3) Newmark's method, finite difference method, and finite element method applied to problems in structural and soil engineering.

540. Advanced Structural Analysis I (3) Analysis of continuous trusses and beams, frames, arches, grids, curved beams, suspension systems and space frames by classical methods.

541. Advanced Structural Analysis II (3) Analysis of continuous beams and frames, grids, slabs, shells and three-dimensional structural and soils problems by finite element methods.

544. Advanced Design of Concrete Structures (3) Concrete working stress, ultimate strength, limit design; test behavior of beams, slabs, columns; simple and continuous prestressed concrete members.

545. Advanced Structural Design (2-4) Steel, aluminum members; flexible connections; composite, hybrid, prestressed beams; tension-field beams; buckling; plastic analysis, design; test data; timber design. Prerequisite: C.E. 41.

546. Thin Concrete Structures (3) Design of thin concrete structures including slabs, folded plates, and shells.

548. Structural Design for Dynamic Loads (3) Dynamic behavior of structural systems of one and more degrees of freedom; earthquake, blast-resistant analysis, and design of structures.

549. Long Span Structures (3) Analysis and design of suspension bridges, cable roofs, and arch-type structures.

550. Engineering Construction Management (2-4) Management fundamentals for construction contracting; organization, project planning, scheduling and control, bonding and insurance, labor legislation and regulation, cost and control. Prerequisite: C.E. 431.

551. Hydrologic Investigations (2-8) Application of hydrologic principles and techniques to a specific project.

552. Hydrologic Processes and Cybernetics (3) Application of cybernetic concepts in electronic computer simulation of the hydrologic process-components: infiltration, precipitation, evapotranspiration, and overland flow. Prerequisite: C.E. 51 or 452.

553. Planning Multipurpose Hydrologic Systems (3) Study of multipurpose hydrologic schemes within a social, economical, and political framework. Prerequisite: C.E. 451 or 452.

554. Urban Hydrology (3) Several hydrograph methods. Design storm and IUH application; airport drainage; flood plains; impact of urbanization upon groundwater and sediment. Prerequisite: C.E. 451 or 452.

560. Dimensional Analysis and Theory of Models (3) Principles of dimensional analysis and similitude with engineering applications.

564. Hydraulic Engineering Design (2-8) Design and analysis of selected units of a typical hydraulic engineering project.

571. Water Treatment Theory (3) Theory of modern methods of conditioning water for municipal and industrial use. Prerequisite: C.E. 472.

572. Waste Treatment Theory (3) Theory of modern methods of waste treatment. Prerequisite: C.E. 472.

573. Problems in Environmental Pollution Control (3-9) Investigations, analyses, and reports on current topics in environmental pollution control.

574. Laboratory Analyses in Water Quality Control (3) Experiments illustrating current chemical and biochemical methods of water and waste treatment and analytical methods used in research and control.

575. Advanced Industrial Waste Treatment (3) Techniques of industrial waste treatment; attendant stream pollution and stream self-purification factors. Prerequisite: C.E. 472 or 572.

576. Water Treatment Plant Design (1-6) Design of works for treatment of water for municipal and industrial use. Prerequisite: C.E. 371.

577. Waste Treatment Plant Design (1-6) Design of works for the treatment of municipal or industrial wastes. Prerequisite: C.E. 371.

579. (Micrb. 529) Aquatic Microbiology (3) Ecology and physiology of microorganisms of inland waters, estuaries, and oceans; microbiology of wastewater treatment. Prerequisite: introductory microbiology.

580. Stream and Estuarine Analysis (3) Quantitative assessment of advection, reaction, and dispersion processes in polluted waters; reaeration theory; eutrophic systems; analog simulation. Prerequisite: C.E. 472.

CLASSICS (CLASS)

Anthony J. Podlecki, *Head of the Department*
121 Carnegie Building

Degree Conferred: M.A.

Graduate Faculty: Senior Members Carrubba and Podlecki.

Graduate Faculty: Associate Members Allen and Donlan.

The master's degree in classics is intended either as a terminal degree which (combined with the appropriate courses in educational theory and technique) equips students to teach at the elementary or secondary school level, or as preliminary to further graduate study at the doctoral level. The program allows specialization in either Latin or Greek but not to the exclusion of the other language. Although 18 undergraduate credits in some combination of Latin and Greek are the normal minimum requirement for admission, candidates can be admitted with deficiencies in the languages if these are compensated by training in ancient history, civilization, or archaeology. The required 2.50 grade-point average in junior-senior courses, normally considered a minimum for admission, will also be waived in special cases.

Of the 30 graduate credits required for the M.A., 6 may take the form of a supervised thesis. Candidates who choose not to submit a thesis must schedule 6 additional credits of course work. Besides the courses listed below, offered by the Department of Classics, candidates may schedule up to 9 credits in appropriate related subjects — such as ancient history, ancient philosophy, art history, or linguistics — offered by the respective departments. The comprehensive examination comprises a translation paper in either Latin or Greek, an essay exam in three areas of the student's choice in Greek and Latin literature, and a reading examination in a modern language (normally French or German).

GREEK (GREEK)

401. Introductory Readings in Greek Literature (3)
420. The Greek Historians (3)
421. Greek Tragedy (3)
422. Greek Comedy (3)
425. Homer (3)
430. The Greek Philosophers (3-9)
431. Plato (3)

450. Topics in Greek Literature (3-6)
451. (Ling. 451) History of the Greek Language (3)
489. Studies in Greek Literature (1-6)

502. Greek and Latin Epigraphy (3) Study of the techniques of epigraphical research; the value of inscriptions for Greek and Roman history and private antiquities.

507. Problems in Greek Archaeology (3-9)

509. Greek Seminar (3-9)

517. Greek Research (1-6) Prosecution of an assigned problem under the guidance of a member of the department.

LATIN (LATIN)

401. Introductory Reading in Latin Literature (3)
420. The Latin Historians (3)
425. Latin Elegy (3)
426. Roman Comedy (3)
427. Vergil (3)
428. Lucretius (3)
430. Medieval Latin (3-6)
431. Roman Satire (3)
432. Roman Rhetorical and Literary Theory (3)
436. The Teaching of Latin (3)
437. Latin Prose Composition (3-6)
461. (Ling. 461) History of the Latin Language (3)
489. Studies in Latin Literature (1-6)

500. Latin Literature (3-9) Readings in the major forms of Latin literature; content varies; course may be repeated.

501. Roman Religion and Philosophy (3) Development of religious concepts at Rome from primitive Italic origins to the advanced forms that culminated in Roman Stoicism. Prerequisites: two 400-level courses in Latin.

510. Latin Seminar (3-6)

518. Latin Research (1-6) Prosecution of an assigned problem under the guidance of a member of the department.

*CLASSICS (CLASS)

405. Greek and Roman Mythology (3)
406. Emergence and Development of Classical Poetic Genres (3)
408. Greek Religion and Modern Man (3)
410. Classical Epic (3)
411. Classical Drama (3)
412. Classical Historians (3)

500. Introduction to Classical Scholarship (1-6) Lectures on the methods and materials of classical scholarship. To be scheduled by graduate students in their first term, and as necessary thereafter.

504. Topography of Ancient Rome (3) Lectures and readings on physical development of the ancient city of Rome from earliest habitation to time of later empire.

*The readings are in English; knowledge of Greek and Latin is not required.

COMMUNITY SYSTEMS PLANNING AND DEVELOPMENT (CSP D)

JOE A. MILLER AND GORDON D. BROWN, *Cochairmen of Coordinating Committee*
104 Henderson Human Development Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Anderson, Arnold, Bortner, Freeman, Gunter, Hunt, Mann, Newman, Raffel, Ritti, and Vallance.

Graduate Faculty: Associate Members Ahmad, Berry, Brown, Bullington, Burns, Duffee, Ellis, Gamm, Guttenplan, Hill, Katkin, Mayers, Meyer, Miller, Robinson, and Woolley.

This interdisciplinary program provides instruction in content and research methods relating to the coordinated planning, development, administration, and evaluation of a range of community services.

The Ph.D. program provides general coverage of the full range of problems and processes in community planning and offers opportunities emphasizing planning, development, and administration in health services, administration of justice services, community organizations, and social welfare services. The M.S. program emphasizes planning, development, and administration in the health services area.

The aim of the program is to build the knowledge base and skills necessary to assist communities to develop policies and programs for services needed by individuals and the community as a whole. Graduates of the program will be able to identify major community subsystems and recognize community problems and dysfunctions, expressing their relative seriousness in terms of economic and social costs. Graduates will have skill in working with community members to develop ways of coping with such problems and to facilitate the creation of interventions which will improve the quality of life. In addition, they will have the skills necessary to evaluate the effectiveness of these programs.

The communication requirement for the Ph.D. can be satisfied by demonstrating proficiency through examination in one foreign language or a set of computer languages.

Preference will be shown to applicants who have a broad background in the social sciences. Proficiency in quantitative skills such as mathematics and statistics is also desirable. In general, a 3.00 junior-senior average is expected of applicants, but consideration will be given to prior graduate education and professional work experience in community services, political processes, or such programs as Peace Corps and VISTA.

Special research and training facilities include the Pennsylvania Field Research Laboratory, the University Computation Center, and a simulation laboratory.

COMMUNITY SYSTEMS PLANNING AND DEVELOPMENT (CSP D)

501. HEALTH CARE ORGANIZATION (3) Examination of health systems, organization, financing, and evaluation; trends, problems, and issues.

521. VALUES AND GOALS IN THE ADMINISTRATION OF JUSTICE (3) The justice system from perspective of clientele, service personnel, and the system. Meeting service requirements in community and institutional settings.

523. ISSUES AND TRENDS IN THE DEVELOPMENT OF SOCIAL WELFARE SERVICES (3-6) Examination of selected issues affecting the development of social welfare functions and services.

532. INTERFACE PROBLEMS OF COMMUNITY SERVICE SYSTEMS (3) Exploration of consequences of policy decisions and action in one or more social service systems on other community systems.

533. Behavioral Assumptions and Strategies in the Process of Planned Change (3) A general systems approach to the assumptions beneath various social problem strategies and consequences associated with each intervention-set.

534. Forecasting Methods and Social Policy Planning (3) Analysis of predictive methods for forecasting social change. Prerequisites: Econ. 405, Stat. 200.

590. Colloquium (1-3)

596. Individual Studies (1-6)

597. Special Topics (1-6)

COMPARATIVE LITERATURE (C LIT)

Robert Lima, *In Charge of Graduate Programs in Comparative Literature*
N-346 Burrowes Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Begnal, Ebbinghaus, Kopp, Lewis, Lima, Rosenberg, and West.

Graduate Faculty: Associate Members Eckhardt, Grecco, Knight, Peavler, Walden, and Ward.

Programs of study in international literary and cultural relations are arranged in accordance with the individual student's interests through a meaningful selection of courses both in comparative literature and in the several national literatures. Topics appropriate to such programs include the currency, reception, and influence of writers and works in countries other than those of their origin; the origin, transmission, and evolution of international literary movements; the characteristics and relations of genres, themes, and motifs; folk literature and folklore; criticism; aesthetics; intermediaries; relationships between literature and other disciplines.

In addition to the general requirements for graduate degrees, there are the following special requisites. *Master of Arts* — Courses in comparative literature (9 credits) and two national literatures (9 and 6 credits), knowledge of the language of each of the two literatures to be demonstrated by examination, a written examination based on a reading list, and a thesis (6 credits). *Doctor of Philosophy* — The communication and foreign language requirement for the Ph.D. degree may be satisfied by courses in comparative literature and three national literatures (one of which may be English), knowledge of the languages of each of the three literatures to be demonstrated by examination. A written comprehensive examination and a doctoral thesis are also required. An M.A. degree in an appropriate area is a prerequisite for entry into the doctoral program. Students with a 2.65 junior-senior average and with appropriate course backgrounds will be considered for admission. Exceptions to the minimum 2.65 grade-point average may be made for students with special backgrounds, abilities, and interests.

COMPARATIVE LITERATURE (C LIT)

401. Western Literature I (3) *Mrs. Eckhardt*
402. Western Literature II (3) *Mr. Knight*
403. Western Literature III (3) *Mr. Begnal*
408. Heroic Epic and Song (3) *Messrs. Rosenberg and Thigpen*
420. Tradition in Modern African Literature (3) *Mr. Hale*
421. Modern African Literature: The Colonial Experience (3) *Mr. Hale*
443. (Ger. 443) Literary Relations of Germany with England and America (3-9) *Messrs. Kopp and Lewis*
470. Old Masters of the Modern Novel (3) *Mr. Begnal*
480. Introduction to Folklore (3) *Mr. Rosenberg*
486. Tragedy (3) *Messrs. Grecco and Lima*
487. Comedy (3) *Mr. Knight*
488. (Engl. 488) Modern Continental Drama (3) *Mr. Grecco*

489. Special Subjects and Problems of Comparative Literature (3) *Staff*

500. Seminar in Comparative Literature (3-6) *Staff*

501. Comparative Method in Literary Studies (3) *Miss Ward*

502. Comparative Criticism I: Classical to Neoclassical (3) Issues in literary criticism from Plato and Aristotle to the mid-eighteenth century. *Miss Ward*

503. Comparative Criticism II: Romantic to Contemporary (3) Principles and theories of literary criticism from eighteenth- and nineteenth-century beginnings to twentieth-century expansion and application. *Miss Ward*

508. Norse and Gaelic Sagas (3) Medieval Irish and Scandinavian prose tales surveyed and compared with respect to background, development, themes, and characteristics. *Mr. Ebbinghaus*

570. Forces in Contemporary European Literature (3) The intellectual currents that have influenced European writers of the mid-twentieth century: Beckett, Böll, Robbe-Grillet, and others. *Mr. West*

588. Twentieth-Century Drama (3) The comparative analysis of major plays of the twentieth century. *Messrs. Grecco and Lima*

593. (Engl. 593) Anglo-American Folk Song (3) Survey of relevant literary and ethnological scholarship and field work, European and American, from the early sixteenth century to the present.

596. Individual Studies (1-6)

COMPUTER SCIENCE (CMPSC)

Patrick C. Fischer, *Head of the Department*
303 Whitmore Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Barnes, Bruno, Coffman, Day, de Maine, Gotterer, Hammer, and Laird.

Graduate Faculty: Associate Members Hofri, Hosken, Hughes, D. Johnson, G. Johnson, Miller, and Sethi.

The department offers courses and is prepared to direct research in a variety of subfields of computer science, including information retrieval, theoretical foundations of computer science, computer languages and programming systems, numerical analysis and nonnumeric procedures. The Computation Center has modern digital equipment and systems available for research and instruction.

Admission to the M.S. program without deficiency requires the equivalent of Cmp.Sc. 401 and 410 and at least four of the six following: (1) Cmp.Sc. 404, (2) Cmp.Sc. 411, (3) Cmp.Sc. 420, (4) Cmp.Sc. 453 or 454, (5) Cmp.Sc. 468, (6) Math. 63 and 441. The remainder of these six must be completed for the M.S. and Ph.D.

The M.S. candidate must satisfactorily complete Cmp.Sc. 510, 511, and 540, in addition to the other requirements of the Graduate School. The nonthesis option is available for the M.S. degree.

The Ph.D. degree is primarily a research degree, and is conferred on the basis of original work and high academic achievement in computer science. In order to be accepted as a candidate the student must pass a six-hour written candidacy examination. The communication and foreign language requirement for the Ph.D. degree may be satisfied by a proficiency in one foreign language (French, German, or Russian). These and additional requirements are detailed in the departmental brochure, *Computer Science at Penn State.*

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degree (see p. 230).

COMPUTER SCIENCE (CMPSC)

401. Principles of Programming with Physical Science Applications (3)
402. Principles of Programming with Social and Biological Science Applications (3)
403. Principles of Programming with Business Applications (3)
404. Information Structures (3)
408. (Chem. 408) Computer Applications in Chemistry (3)
410. Introduction to Computer Systems (3)
411. Systems Organization and Programming (3)
420. The Structure of Programming Languages (3)
430. Combinatorics and Graph Theory (3)
450. Information Theory and Error-Correcting Codes (3)
453. (Math. 453) Numerical Computations (3)
454. (Math. 454) Matrix Computations (3)
468. Mathematical Machine Theory (3)
490. Special Topics in Computer Science (1-9)
491. Computer Projects (3)

500. Theory of Automata (3) The structure of finite automata and sequential machines including characterization theorems, minimization problems, state identification experiments and decomposition theory. Prerequisite: Cmp.Sc. 468.

501. Algebraic Theory of Automata (3) Prerequisite: Cmp.Sc. 500.

510. Structure of Artificial Languages (3) Structure of problem-oriented languages; syntactical description, algorithms for translation, list structures, string manipulation, formula manipulation, relation to linguistics. Prerequisites: Cmp.Sc. 420, 468.

511. Systems Programming (3) Interpretive systems; assemblers, loaders, compilers, library monitor systems; input-output scheduling; executive programs, job scheduling; multiaccess systems, multiprogramming, multiprocessing. Prerequisite: Cmp.Sc. 411.

530. Nonarithmetic Programming (3) Combinatorial problems, learning mechanisms, heuristic programs, and pattern recognition. Prerequisite: Cmp.Sc. 420.

535. Theory of Graphs and Networks (3) Theory and applications of graphs including structure of graphs, network analysis and algorithms for computer solution of graph-theoretic problems. Prerequisite: Cmp.Sc. 430.

537. (B.A. 537) Management Information Systems Design (3) Cost, value, and technical considerations in analysis and design of information systems whose purposes are to aid decision making in organizations.

540. Information Processing Systems (3) Data structures and data processing; information retrieval systems. Prerequisite: Cmp.Sc. 411.

545. Information Retrieval (3) This course deals with input-output, design implementation, evaluation, global memories and comparison of information retrieval systems. Prerequisite: Cmp.Sc. 540.

552. (Math. 552) Numerical Analysis I (3) Interpolation; remainder theory; approximation of functions; error analysis; orthogonal polynominals; approximation of linear functionals; functional analysis applied to numerical analysis. Prerequisites: Math. 420, 453.

553. (Math. 553) Numerical Analysis II (3) Eigenvalue and eigenvector determination; numerical solution of integral equations and ordinary differential equations with error and stability analysis. Prerequisites: Math. 420; 454 or 480.

559. Computability and Recursive Functions (3) Mathematical treatment of computability, recursive functions, Turing machines, unsolvable problems, recursive and recursively enumerable sets. Prerequisite: Cmp.Sc. 468.

560. Combinatorial Systems (3) The relationships among various forms of combinatorial systems including Turing machines, Post normal systems, Thue systems and recursive functions. Prerequisite: Cmp.Sc. 559.

563. (Math. 563) Approximation Theory (3) Approximation in normed spaces; existence, uniqueness, characterization, computation of best approximations; error bounds; degree of approximation; approximation of linear functionals. Prerequisites: Math. 453, 501.

564. (Math. 564) Numerical Solution of Partial Differential Equations (3) Numerical solution of initial and boundary-value problems; eigenvalues and eigenfunctions; errors, stability, and convergence. Prerequisite: Math. 552.

566. (E.E. 566) Algebraic Coding Theory (3) Polynomial rings, galois fields, linear codes, cyclic codes, BCH codes, finite projective geometry cyclic codes, convolution codes, graph theoretic codes. Prerequisite: Cmp.Sc. 450 or E.E. 561.

568-569. Theory of Formal Languages and Automata (3 each) Generation and recognition of formal language, grammar, Chomsky's hierarchy of languages, closure properties, characterization by automata, algebraic properties, complexity classification. Prerequisite: Cmp.Sc. 468.

579. (Math. 579) Special Topics in Numerical Analysis (2-12)

590. Colloquium (1-3)

591. Special Topics in Computer Science (2-6)

596. Individual Studies (1-6)

597. Special Topics (1-6)

COUNSELOR EDUCATION (CN ED)

Edwin L. Herr, *Head of the Department*
323 Social Sciences Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Britton, Herr, Hudson, Hylbert, Kelz, Swisher, and Wellington.

Graduate Faculty: Associate Members Horan, Keat, and Upcraft.

Professional preparation is offered at the master's level for school counselors (elementary and secondary), college counselors or persons entering college student personnel services, and rehabilitation counselors. Doctoral programs prepare candidates for positions of responsibility and leadership in these same areas as well as in the education of counselors. Doctoral candidates must have a minimum of one year's work experience in their field.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign languages.

All candidates for graduate degrees in counselor education must present for admission at least 27 undergraduate credits of 3.00 or better distributed among at least three of the following areas: economics, education, psychology, sociology, and physiology or anatomy.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average

may be made for students with special backgrounds, abilities, and interests. Doctoral candidates should present a 3.33 average in all graduate study completed.

All candidates are expected to exhibit, in addition to academic competence, effectiveness in interpersonal relations and in both written and oral communication. They must also evidence support of professional counseling activities and organizations.

A candidate for either a Ph.D. or a D.Ed. degree must earn at least 30 credits in six or fewer consecutive terms in residence after completing the master's degree, preferably at the thesis planning and writing stage.

COUNSELOR EDUCATION (CN ED)

403. Foundations of Guidance and Counseling Processes (3)
404. Group Procedures in Guidance and Counseling (3)
408. Introduction to Vocational Rehabilitation (3)
409. Medical Information for Counselors (3)
410. Rehabilitation of the Mentally Ill (3)
412. Rehabilitation Facilities and Services of Pennsylvania (3)
413. Rehabilitation Case Recording and Management (3)
425. The Use of Tests in Counseling (3)

501. Counseling: Theory and Method (3) Theory and methods of counseling individuals whose problems of choice, decision, and adjustment fall within the normal range. Prerequisite: Cn.Ed. 403 or 408 or 551.

503. Guidance Services in Elementary Education (3) Guidance services to elementary school students; guidance opportunities for elementary teachers and principals. Prerequisite: Cn.Ed. 403.

504. Guidance Services in Secondary Education (3) Nature and scope of guidance in secondary schools — services, models, and strategies; the counselor as an agent of change. Prerequisite: Cn.Ed. 403.

505. Foundations of Counseling Information (3) Accelerating change in economic, psychological, social, educational influences upon counselees. Utilization of information systems in effecting counselee change. Prerequisite: Cn.Ed. 403 or 408 or 504 or 551.

506. Individual Analysis and Counseling Procedures (3) Collection and use of data basic to the counselor's understanding of individuals; the counseling interview and techniques other than testing. Prerequisites: Ed.Psy. 451; Cn.Ed. 408 or 503 or 504.

507. Counseling Practicum (1-6) Practice in the application of guidance principles and methods to cases counseled under supervision; case conferences; seminar in guidance techniques. Prerequisite: Cn.Ed. 506.

508. Organization and Administration of Guidance Programs (3) Principles, organization, personnel, functions, integration with school programs, evaluation. Prerequisite: Cn.Ed. 506.

509. Contributions of Professional Personnel to Vocational Rehabilitation (3) Contributions of medical, social, psychological, and other specialists through the team approach; professional ethics, medical problems. Prerequisites: Cn.Ed. 403, 408.

511. Supervised Practicum in Rehabilitation Counseling (1-6) Application of principles and techniques of rehabilitation counseling to cases involving handicapped individuals. Prerequisites: Cn.Ed. 403, 408.

512. Professional Experience in Rehabilitation Counseling (1-6) Supervised internship with responsibility for a regular case load. Prerequisites: Cn.Ed. 403, 408.

513. Supervision of Counselors (3-9) Practical experience in supervising and evaluating work of counselors. Prerequisite: Cn.Ed. 507.

514. Evaluation of Projects in School Guidance (2-6) The analysis of factors in and the completion of program development projects in cooperation with state or local guidance programs. Prerequisite: 15 credits in counselor education.

515. Seminar in Counseling, Guidance, and Rehabilitation (1-9) Conferences and discussions designed to meet the need for special study of particular topics in counseling, guidance, and rehabilitation. Prerequisite: 9 credits in counselor education.

516. Evaluation of Projects in School Guidance (2-6) Implementation and evaluation of program development projects in cooperation with state or local guidance programs. Prerequisite: 15 credits in counselor education.

551. Student Personnel Services (2-3) Student personnel services in higher education; organization of student advisory programs; use of personnel data; cocurricular activities; student welfare.

553. Student Personnel Services Programming (2-3) Formulation of policies as guides to the student personnel service programs; integration of program elements; research; current problems and trends. Prerequisites: Cn.Ed. 551, Hi.Ed. 545.

589. Problems, Projects, and Area Studies in Counselor Education (1-6) Independent work in the study of topics in counselor education, or development of new curriculums, materials, or procedures for teaching.

591. Seminar in Counseling: History and Trends (1) Discussion of the history of guidance and counseling, emphasizing how the past has shaped the present and portends the future. Prerequisite: 9 credits in counselor education.

592. Seminar in Counseling: Legal and Ethical Concerns (1-2) Study and discussion of legal, ethical, and professional concerns of counselors; privileged communication, data banks, and privacy invasion. Prerequisite: 9 credits in counselor education.

593. Seminar in Counseling: Philosophy (1) Study and discussion of such philosophical foundations of counseling as phenomenology, idealism, realism, existentialism, daseinanalytic, theological, and other contemporary thoughts. Prerequisite: 9 credits in counselor education.

DAIRY SCIENCE (D SC)

Donald V. Josephson, *Head of the Department*
111 Borland Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Almquist, Amann, Dimick, Flipse, Josephson, Keeney, Kesler, Kroger, McCarthy, Patton, Tanabe, and Watrous.

Graduate Faculty: Associate Members Buckalew, Glass, Hargrove, Ostovar, Shellenberger, and Thoele.

Students may specialize in dairy products manufacture, chemistry of milk and dairy products, lipid metabolism, dairy cattle nutrition, dairy cattle genetics, dairy cattle management, and physiology of reproduction. The minor program is generally taken in biochemistry, microbiology, physiology, or agricultural economics. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Prerequisite to graduate work is the completion of an undergraduate major in animal industry, animal science, dairy science, food technology, or a related area. The undergraduate program must include college algebra and general physics. Students may be admitted with limited deficiency but are required to make up undergraduate deficiency work without degree credit.

Students with a 2.70 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of

spaces that are available for new students. Exceptions to the minimum 2.70 grade-point average may be made for students with special backgrounds, abilities, and interests.

DAIRY SCIENCE (D SC)

405. Dairy Cattle Management (3) *Mr. Buckalew*
418. Dairy Survey (1) *Mr. Shellenberger*
427. Milk Secretion (1) *Mr. Kesler*
428. Dairy Production Problems (1-6) *Mr. Kesler and Staff*
431. Physiology of Reproduction in Farm Animals (3) *Messrs. Almquist and Amann*

507. Dairy Cattle Management (1-6) *Mr. Buckalew and Staff*

508. Dairy Seminar (1-6) Preparation and presentation of a paper on an assigned subject.

511. Dairy Cattle Nutrition (1-6) Nutritional requirements of dairy cattle. Prerequisite: A.Ntr. 401. *Mr. Kesler*

512. Advanced Studies in Milk Secretion (1-6) Physiology of milk secretion. Prerequisite: D.Sc. 427. *Mr. Kesler*

513. Dairy Cattle Breeding (1-6) Interpretation and application of current knowledge in genetics to dairy cattle breeding and selection. Prerequisites: An.Sc. 322, Biol. 422, 3 credits in statistics. *Mr. Hargrove*

515. Advanced Physiology of Reproduction in Farm Animals (1-6) *Mr. Almquist*

516. Artificial Breeding of Farm Animals (1-6) Prerequisite: D.Sc. 431. *Mr. Almquist*

517. Dairy Science Literature (1-6) Review and reporting of dairy literature. *Staff*

521. Dairy Radiophysiology (3) Metabolism and physiology of radioactive compounds; their use as tracers in animal physiology and the effects of radiation on metabolic processes. Prerequisite: Chem. 405. *Mr. McCarthy*

Note: *See Animal Science under "Other Elective Graduate Courses." Also see Food Science.*

DEVELOPMENTAL AND REMEDIAL READING (D R R)

Arthur W. Heilman, *In Charge of Graduate Program in Developmental and Remedial Reading*
230 CEDAR Building

Degree Conferred: M.Ed.

Graduate Faculty: Senior Members Bliesmer, Golub, and Heilman.

Graduate Faculty: Associate Members Dupuis and Ysseldyke.

The purpose of the master's program is to prepare classroom teachers in elementary and secondary schools for more effective teaching of reading and to provide preparation for supervisory and administrative positions relative to reading in school systems.

Candidates for a master's degree must meet the requirements for admission to graduate study and, in addition, (1) must hold, or be eligible to hold, a valid teaching certificate (persons not meeting this criterion may work on overcoming deficiencies; graduate credit, but not degree credit, may be received for graduate courses taken to overcome such deficiencies) and (2) must have had at least one year of teaching experience or the equivalent.

The master's program has been planned so that those completing the program will also meet the state requirements for "reading specialist" certification.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of

spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

DEVELOPMENTAL AND REMEDIAL READING (D R R)

441. Fundamentals of Reading Instruction (3)
442. Reading Problems in the Secondary Schools (2)
444. Practicum in Elementary Remedial Reading (3)
445. Practicum in Secondary Remedial Reading (3)
446. Remedial Reading in the Classroom (3)
447. Teaching Reading and Literature to Adolescents (3)

540. Teaching Reading: Linguistics Perspective (3) Examination of reading as language and thought processes; contributions of linguistics, orthography, semantics, and syntax to instructional strategies. Prerequisite: undergraduate reading course and teaching experience.

545. Diagnostic Testing in Reading (3) Practicum in diagnosing reading difficulties, elementary and secondary levels; achievement, diagnostic, and capacity tests; informal inventories; genesis of reading problems. Prerequisites: El.Ed. 443 and D.R.R. 444 or 445.

546. Reading Instruction (3-6) Research, procedures and materials in reading readiness, word perception, basic reading skills, vocabulary development, reading in content subjects. Prerequisite: 6 hours of graduate credit in D.R.R.

557. Practicum: Remedial Procedures and Diagnosis (3-6) Advanced practicum; diagnostic testing and remedial instruction of more severe types of reading disability; newer and special materials and procedures. Prerequisite: D.R.R. 545.

559. Studies of Research in Reading (3) Intensive study of research in such areas as vocabulary; readiness; instructional approaches; rate; measuring capacity; readability; difficulty causes; sex differences. Prerequisite: 6 hours of graduate credit in D.R.R.

580. Studies in Developmental and Remedial Reading (1-6) Independent and intensive study of topics in reading which relate to research, instructional trends, new materials and total curricular programs. Prerequisite: 9 hours of graduate credit in D.R.R.

596. Individual Studies (1-6)

EARTH SCIENCES (EARTH)

E. Willard Miller, *Chairman of the Committee on Earth Sciences*
101 Mineral Sciences Building

Degrees Conferred: D.Ed., M.Ed.

Graduate Faculty: Senior Members Blackadar, Cuffey, Dutton, Guber, Lewis, Miller, Panofsky, Thornton, Weber, Wernstedt, Williams, and Wright.

Graduate Faculty: Associate Members Hovermale, Lavin, J. Pena, and R. Pena.

The M.Ed. program is designed to meet the needs of science teachers in secondary schools. The fields of study are astronomy, geography, geology, geophysics, meteorology, and mineralogy. The student selects one of the earth sciences as an area of concentration, takes at least 12 credits in it, and is required to write a term paper in that area. An additional 12 credits must be taken in at least two other fields of earth sciences, or in two earth science fields plus two courses selected from the biological sciences, chemistry, mathematics, or physics. Furthermore, 6 credits in educational foundations are required as a minor.

The D.Ed. program is designed for secondary school and college science teachers. The major course requirements are designed by the candidate's committee with one area of concentration in the earth sciences plus courses from at least two other earth science areas. The program is

designed to investigate problems which arise from the complex interaction of man's technological and social activities with the natural environment. A minimum of 15 credits each is required in professional education and in thesis research.

Students with a 2.50 junior-senior average, 18 credits in education and related psychology, and with other appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

The following courses offered by the various departments are appropriate for students majoring in earth sciences: Astro. 430; Geog. 433, 434; Geol. 400, 401, 402; Gphys. 400; Meteo. 400, 401, 403, 404; Min. 402.

EARTH SCIENCES (EARTH)

400. Earth Sciences Seminar (3)

500. Earth Sciences Research (1-6) Relationships between the earth sciences revealed by theory, analytical methods, or a selected problem.

ECOLOGY (ECLGY)

Edwin L. Cooper, *In Charge of Graduate Programs in Ecology*
315 Life Sciences I Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members P. Baker, Bellis, Butler, Cooper, Cuffey, Dunson, George, Graves, Guber, Hower, Hutnik, Kim, Lindzey, MacCluer, McDonnell, Patil, Rothenbacher, Schein, Shipman, and F. Williams.

Graduate Faculty: Associate Members Adams, R. Anthony, Arnold, and DeWalle.

This intercollege program emphasizes the properties of ecosystems by focusing attention on interactions of single organisms, populations, and communities with their environment. It is designed to give students a basic understanding of ecological theory and is, therefore, complementary to other environmental programs which emphasize man's role in ecosystems.

The instructional program includes three graduate core courses in ecology, augmented by an additional integrated group of seminars and courses selected for each student by his committee, and a research project directed by the thesis adviser. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language. The nonthesis option is available for the M.S. degree.

The program is administered by a committee drawn from faculty members in several departments and Colleges of the University. This committee and its chairman are appointed by the Dean of the Graduate School. The instructional staff is composed of participating faculty in those departments offering graduate courses in fields closely allied to ecology.

The committee appointed by the Graduate School for each candidate in ecology is selected from members of the program committee and faculty from the student's area of specialization. The committee has the responsibility for determining the course program and research acceptable in satisfying degree requirements.

Students meeting the admission requirements of the Graduate School will be considered up to the number of spaces available in selecting candidates in this program. Candidates should have a strong science background including chemistry, physics, and mathematics. Preparation in biological sciences is also desirable. Students with a unique background in another discipline which has potential value to original ecological work will be seriously considered.

Detailed descriptions of courses now available for students majoring in ecology may be found under the offerings of several departments: Anthy. 502-503; Biol. 433, 435, 450, 451, 480, 481,

516, 519, 545, 546; C.E. 472, 579, 580; Cmp.Sc. 402; Ent. 416, 517, 535; E.R.M. 410 413; For. 508, 517; Geol. 430, 435, 503; G.Sc. 547; Meteo. 505; Micrb. 400, 413, 529; Phil. 512; P.Path. 424; Stat. 524; V.Sc. 401; Wildl. 446.

ECONOMICS (ECON)

GRANT N. FARR, *Head of the Department*
613 Kern Graduate Building

Degrees Conferred: Ph.D., M.A., M.Ed.

Graduate Faculty: Senior Members Budd, Coppock, Farr, Feller, Herendeen, Hu, Kaufman, Klein, Mason, Myers, Newman, Prybyla, Riew, Robinson, Rozen, Sauerlender, Smith, and Stout.

Graduate Faculty: Associate Members Booms, Cathcart, Coelen, Cohn, Ferrar, Fox, Friedrich, Glyde, Latham, McIntyre, Nelson, Rodgers, Rosenberg, and Soladay.

Opportunities are available for concentration in the following fields: economic analysis, economic doctrines, economic development of developed areas, economic development of underdeveloped areas, economic fluctuations, income distribution, industrial organization, international economics, comparative economic systems, labor economics, money and banking, public finance, quantitative economics, statistics, and regional economics.

Students may also qualify for admission to the program in population issues, consisting of interdisciplinary course work with special emphasis on the economic, social, and geographic issues arising from the dynamics of population change.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by any of the following alternatives: (1) a reading knowledge of two foreign languages, (2) a reading knowledge of one foreign language and 6 credits of other course work from designated areas which increase research skills, (3) the equivalent of 12 credits of departmentally approved course work which increases research skills, or (4) a comprehensive knowledge of one foreign language. The nonthesis option is available for the M.A. degree.

To enter graduate work in economics a student should have completed 6 credits in economic principles, 9 in the social sciences, and either 3 in statistics or 6 in mathematics. All applicants must take the Graduate Record Examination in advanced economics and general aptitude.

Students with a 2.50 junior-senior average, a 3.00 average in courses in economics, and appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 230).

ECONOMICS (ECON)

400. HISTORY OF ECONOMIC THOUGHT I (3)
401. HISTORY OF ECONOMIC THOUGHT II (3)
404. CURRENT ECONOMIC ISSUES (3)
405. ADVANCED ECONOMIC ANALYSIS (3)
412. ECONOMICS OF COLLECTIVE BARGAINING (3)
413. (L.S. 413) COMPARATIVE LABOR MOVEMENTS (3)
414. (L.S. 414) THEORIES OF THE LABOR MOVEMENT (3)
415. SOCIAL INSURANCE (3)
418. ECONOMICS OF WAGES AND EMPLOYMENT (3)
419. CASE STUDIES IN LABOR-MANAGEMENT RELATIONS (3)
423. STATE AND LOCAL TAXATION (3)
424. URBAN ECONOMICS (3)

425. Economics of Public Expenditures (3)
427. (Ed.Adm. 427) Economics of Education (3)
429. Advanced Public Finance (3)
433. International Monetary Economics (3)
435. Labor Relations in the Public Sector (3)
442. Monopoly, Competition, and their Regulation (3)
450. The Business Cycle (3)
451. Monetary Theory and Policy (3)
461. Economic Growth: Underdeveloped Areas (3)
462. Economic Growth: Theories of United States Development (3)
463. Economic Demography (3)
480. Mathematical Economics (3)
489. Selected Topics in Economics (3)
490. Introduction to Econometrics (3)
491. Analysis of Linear Economic Models (3)
499. Foreign Study in Economics (2-6)

500. Economic Seminar (3-6)

502. Microeconomic Analysis (3) Economic behavior under pure and imperfect competition; price and output determination in product markets; prices and employment in factor markets.

503. Macroeconomic Analysis (3) National income accounts; determination of income, employment, interest rates, and the price level; stabilization policy.

506. Problems in Economics (1-12) Planned projects involving library, laboratory, or field work.

507. International Trade (3) A survey of international trade theory including modern developments of pure theory, and of international trade policy.

508. Current Monetary Theory and Policy (3) Post-Keynesian reformulation of quantity and Keynesian theories of money; liquidity and general equilibrium approaches; current issues in theory and policy.

510. Econometrics (3-6) Statistical estimation in mathematically formulated economic relationships.

513. Development of Economic Doctrines (3-6)

515. Economics of the Labor Market (3) Theory and problems of labor-management relations; selected problems of the labor market with reference to current research and developments.

516. Economics of Human Resources (3) Analysis of changes in human resource supply and demand; factors affecting these changes; current human resource policies.

517. International Finance (3) Problems of international liquidity; balance of payments adjustment; international financial institutions and selected policy problems.

518. Development of Monetary Theory (3) Classical and neoclassical quantity theories of money and contemporary criticism; Keynesian monetary theory and its critics.

521. Advanced Microeconomic Theory (3-6) Theory of consumer behavior; theory of the firm; price determination in product and factor markets; introduction to welfare economics.

522. Advanced Macroeconomic Theory (3-6) Measurement of income; theories of consumption, investment, and money holdings; static determination of income and employment; introduction to dynamic analysis.

524. Income Distribution (3) Measurement of inequality; ethical issues in income redistribution; measurement and determination of distributive shares; problem of poverty.

525. Economics of Technological Change (3) Theoretical and empirical analysis of invention and innovation and their effects on productivity, employment, and market structure.

528. Advanced Economic Theory: Selected Topics (3) Treatment of topics in economic theory to meet needs of advanced students seeking intensive work in selected areas.

529. Public Finance (3-6) Contemporary problems in public finance; instruments of fiscal policy in the achievement of full employment, price stability, and economic development.

530. Regional Microeconomics (3) Theoretical and empirical analysis of industrial location as determined by costs, markets, and agglomeration effects.

531. Regional Macroeconomics (3) Aggregate regional trade flows; sources of regional economic data; techniques for measuring regional economic activity; long-run regional growth.

543. Industrial Organization and Public Policy (3) The structure of American industry; performance and behavior; public policies toward business.

550. Economic Fluctuations (3) Analysis of the various theories of economic fluctuations; their methodological premises.

551. Stabilization Policy (3) Description and analysis of the alternatives and issues in stabilization policy.

560. Seminar in Economic Growth: Underdeveloped Areas (3-6) Resources and institutions; quantitative measures; theories of economic growth in developing areas; developmental policies.

561. Seminar in Economic Growth: Developed Areas (3-6) Growth models; strategic factors in growth; quantification problems; public policy.

571. Comparative Economic Systems (3-6) Comparative analysis of alternative resource allocation principles; growth and performance of different economic systems; problems of decision making and control.

572. Soviet and Other Centrally Planned Economies (3-6) Principles, structure, and performance of centrally planned economies with special emphasis on the Soviet Union.

580. Mathematical Economics (3-9) Mathematical development of static and dynamic economic models: partial and general equilibrium analysis; growth dynamics; mathematical programming. Prerequisite: Econ. 480.

EDUCATION OF EXCEPTIONAL CHILDREN (E E C)

Joseph L. French, *In Charge of Graduate Programs in Education of Exceptional Children*
102 CEDAR Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Bliesmer, G. Cartwright, French, Frick, Heilman, McDonald, Sabatino, Siegenthaler, and Smith.

Graduate Faculty: Associate Members Abbott, Axelrod, Berlin, C. Cartwright, Herr, Salvia, Vitello, Ward, and Ysseldyke.

Exceptional children are those who deviate so far from average in physical, intellectual, emotional or social characteristics that they cannot profit adequately from the usual public school program. It is the purpose of this program to prepare teachers, researchers, administrators, and college and university teachers in the areas encompassing the education of the mentally retarded, gifted, emotionally disturbed, neurologically impaired, or learning disabled. A multidisciplinary approach is emphasized. The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign languages.

Prerequisites for a master's program include: 24 credits basic to the education of exceptional children (courses comparable to D.R.R. 441; E.E.C. 400, 401, 403, 454, 410 or 430 or 470;

Mth.Ed. 420; a 400-level course in child development or child psychology; and a 400-level course in foundations of education).

Highest admission priorities are given to applicants who possess certification in special education or elementary education. Applicants for master's and doctoral programs must present evidence of superior academic achievement and aptitude, complete a personal statement, and provide professional references. Applicants for doctoral study must have had at least two years relevant experience with handicapped children.

EDUCATION OF EXCEPTIONAL CHILDREN (E E C)

400. Introduction to Exceptional Children (3)
401. Educational Adjustments for Exceptional Children (3)
403. Clinical Teaching with Exceptional Children (3)
405. Practicum in the Education of Exceptional Children (1-12)
410. The Mentally Retarded (3)
420. The Mentally Gifted (3)
430. Learning Disabilities (3)
440. (S.P.A. 440) Survey of Speech and Hearing Disorders (3)
454. Diagnosis of Educational Disabilities (3)
460. Education of Visually Handicapped Children (1)
470. The Emotionally Disturbed (3)
472. Educational Problems of Alienated Youth (3)
480. The Neurologically Impaired (3)
496. Workshop in Special Education (1-9)

500. Seminar in Special Education (1-9) Continuing series of professional seminars designed to provide a forum for discussion of current and classical research concerning exceptional children. Prerequisites: Ed.Psy. 400 and 6 credits in education of exceptional children.

501. Administration and Supervision of Educational Programs for Exceptional Children (2-3) Problems connected with the instituting and organizing of classes for atypical children; the legal phases, finances, teaching personnel, pupil personnel, housing, equipment, courses of study, curriculum, etc. Prerequisites: E.E.C. 401 and Ed.Adm. 480, or teaching or administrative or supervisory experience.

502. Internship in Special Education (2-10) Internship to take place in schools or educational situations where student is not regularly employed, under supervision of graduate faculty. Prerequisite: E.E.C. 405 or teaching experience.

505. Practicum (1-6) Supervised clinical experience on campus in University-managed diagnostic and remedial settings.

506. Field Experiences in Off-Campus Laboratories (1-10) Supervised off-campus field experiences in selected laboratory settings with exceptional children. Prerequisite: E.E.C. 505.

509. Problems, Projects, and Area Studies in Special Education (1-9) May not be used for thesis credit. Prerequisite: 12 graduate credits in special education.

510. Problems in the Education of the Mentally Retarded (2-4) Study of existing curriculums, instructional practices, educational programs; experimentation in curriculum building and materials construction. Prerequisites: teaching experience and E.E.C. 410.

520. Problems in the Education of the Mentally Gifted (2-4) Analysis of educational needs of the mentally gifted; curriculum construction and curricular materials. Prerequisites: teaching experience and E.E.C. 420.

530. Problems in the Education of the Learning Disabled (2-4) Review of the research and theoretical implications in the educational and behavioral management of learning disabled children. Prerequisite: E.E.C. 430.

545. (S.P.A. 545) Cerebral Palsy (3) Etiology and symptomatology of cerebral palsies; diagnosis and treatment of communication problems; the multiprofessional habilitative program. Prerequisite: S.P.A. 444.

547. (S.P.A. 547) Language Disorders in Children (2) Nature, etiology, diagnosis, and management of language disorders in children. Prerequisite: 9 credits in speech pathology and audiology or related fields such as psychology, linguistics, or human development.

554. Psychological and Educational Evaluation of Exceptional Children (3) Administration and interpretation of individual tests other than the Stanford-Binet, WISC, WAIS. Prerequisite: Psy. 559.

570. Problems in the Education of the Emotionally Disturbed (2-4) Prerequisite: E.E.C. 470.

572. Seminar in the Education of Alienated Groups (2) A study of the alienated and educational issues of coping with problems of social, cultural, and economic deprivation. Prerequisite: E.E.C. 472.

573. Problems of Research with Alienated Groups (2) A seminar to review and design research studies for the education and training of alienated groups. Prerequisites: E.E.C. 472, 572.

580. Problems in the Education of the Neurologically Impaired (2-4) Prerequisite: E.E.C. 480.

596. Individual Studies (1-6)

EDUCATIONAL ADMINISTRATION (EDADM)

Patrick D. Lynch, *In Charge of Graduate Programs in Educational Administration*
318 Rackley Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Caldwell, DeLacy, Hayman, Lutz, Lynch, and Willower.

Graduate Faculty: Associate Members Carter and Johnson.

Professional preparation programs are offered at the master's and doctor's degree levels for elementary and secondary school personnel whose objectives are to become prepared in education policy-making positions such as principals, supervisors, superintendents, intermediate unit officials, state and federal education agency personnel, professors of educational administration, and/or researchers in educational administration.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign and native American languages.

Requirements for admission to a graduate program in educational administration ordinarily include 18 approved undergraduate credits in education and psychology. Students with a 2.60 junior-senior average and with appropriate course backgrounds will be considered for admission. All applicants for any graduate program, including certification, must submit either a Miller Analogies Test or Graduate Record Examination (Quantitative and Verbal) score. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.60 grade-point average may be made for students with special backgrounds, abilities, and interests.

All candiates who seek M.Ed. and M.S. degrees in educational administration shall complete programs embracing a minimum of 30 graduate credits. In only rare instances, however, to fulfill unusual objectives, will candidates be permitted to work toward the M.S. degree. In Pennsylvania a certification program consisting of at least 45 credits is required before one can become a public school administrator.

Candidates for the D.Ed. and Ph.D. degrees are required to complete a minimum of three consecutive terms in residence.

From the time of initiation of a 600-level thesis research program, all doctoral candidates shall continuously register for a minimum of 2 credits per term until the termination of the graduate program. Failure to register for doctoral thesis credits in any term shall be considered automatic withdrawal. Specific requirements with respect to the Ph.D. and D.Ed. degrees may be learned from a departmental bulletin that is available upon request. Although candidates are required to specialize in a field of educational administration, they are encouraged to acquire a general education in the social sciences and the humanistic foundations.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 230).

EDUCATIONAL ADMINISTRATION (EDADM)

427. (Econ. 427) Economics of Education (3)
460. (Hi.Ed. 460) Introduction to Adult Education (3)
480. Educational Administration (2-3)
481. Collective Negotiations in Public Education (3)

525. Federal Education Policies (3) Analysis of federal role in development of educational policy and its relationship to state and local policy.

528. (Pl.Sc. 528) Politics and Education (3) Social forces which shape the educational system and determine national, state, and local educational policies.

533. The Politics of Local School Districts (3) The methodology of studying political decision making and the theory and practice of politics in local school districts. Prerequisite: 6 credits of sociology, anthropology, or political science.

560. System Theory in Education (3) Concepts of general system theory, the systems approach, and related methodologies and tools; applications in education; critique of instructional systems. Prerequisites: Ed.Psy. 400, 475.

565. Personnel and Grievance Administration (2-3) Practice and theory of personnel supervision at the central office and building level, including contract administration and grievance handling. Prerequisites: 18 credits in education and three years' teaching experience.

567. Organizational Supervision (3) The organizational context of the school, its relationship to supervision, and the improvement of instruction. Prerequisites: Ed.Adm. 480 and teaching experience.

568. The Principalship (2-3) For elementary and secondary principals. The administrative and management tasks of building administration. The social system, change, and community relationships.

569. Principalship Seminar (2-3) The study and application of interdisciplinary-based products and processes in the various organizational units within the educational system.

571. The Educational Plant (2-3) School plant needs in terms of school population and curriculums; the building survey, developing a plant program, the building site, plant utilization, operation and maintenance, heating and ventilation, equipment, school building costs and finance. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.

572. Analysis of School-Community Relations (2-3) School-community relationships; social structure, social change, and the schools; case studies of community-school problems. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.

573. Public School Finance (2-3) Financing of public education in relation to organization and control; the conceptual basis for local financial administration; taxation, state and federal aid, school revenue, and money management. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.

574. THEORY AND PRACTICE OF EDUCATIONAL NEGOTIATIONS (2-3) Theoretical framework, bargaining strategies, legislation, administrative roles, agreements, etc. Prerequisites: Ed.Adm. 480 or teaching or administrative or supervisory experience, and previous work in school administration.

575. ADMINISTRATION OF ADULT EDUCATION IN THE PUBLIC SCHOOLS (3) The organization of a program of adult education; its legal status, finances, selection of teachers, learning personnel, housing, and other administrative problems connected with adult education. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.

576. LEGAL ASPECTS OF SCHOOL ADMINISTRATION (3) Legal bases for the organization and administration of school districts and schools; the powers, rights, privileges, and responsibilities of school corporations, school boards, administrators, and personnel; the law and fiscal policies, the course of study, textbooks; contracts; taxes, torts; records; agents; and the judicial decisions involved. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.

577. ECONOMIC DIMENSIONS OF EDUCATIONAL ADMINISTRATION (3) Application of selected economic concepts and tools of analysis to administrative decision and planning processes in educational systems. Prerequisite: Ed.Adm. 480.

578. DYNAMIC FACTORS IN SCHOOL ADMINISTRATION (2-3) Intraorganizational relationships; administration and the school as a social system; formal and informal organization. Prerequisite: Ed.Adm. 480 or teaching or administrative or supervisory experience.

579. PUBLIC SCHOOL BUSINESS ADMINISTRATION (2-3) Business management applied to school management problems; budgeting, accounting, purchasing, insurance, school equipment, cafeteria management; transportation, salaries, personnel management, and auxiliary and coordinate agencies. Prerequisites: Ed.Adm. 480 or teaching or administrative or supervisory experience; Ed.Adm. 573.

580. THE USE OF THEORY IN EDUCATIONAL ADMINISTRATION (1-6) Administrative theories applied to educational organizations. Prerequisites: Ed.Adm. 480, 6 credits in educational administration.

581. FIELD RESEARCH IN EDUCATIONAL ADMINISTRATION Methods of appraisal of an educational program; planning for expansion, consolidation, or reduction of educational offerings. Prerequisites: Ed.Adm. 480, 6 credits in educational administration.

582. INTERNSHIP IN ADMINISTRATION AND SUPERVISION (1-12) Internship to take place in schools or educational situations where student is not regularly employed, under supervision of graduate faculty.

588. WORKSHOP IN CURRENT EDUCATIONAL PROBLEMS (1-6) For administrators, supervisors, experienced elementary and secondary teachers, guidance workers; administrative, supervisory, and instructional problems involved in an emerging educational program. Prerequisite: 12 credits of graduate work in education.

589. PROBLEMS, PROJECTS, AND AREA STUDIES IN EDUCATIONAL ADMINISTRATION (1-6) Independent work in the study of topics in educational administration, or development of new curriculums, materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of the department head.

591. SEMINAR IN PUBLIC SCHOOL RESEARCH (1-4) Doctoral candidates present outlines of their theses to the Graduate Faculty of the department and advanced graduate students.

596. INDIVIDUAL STUDIES (1-6)

EDUCATIONAL PSYCHOLOGY (EDPSY)

WILLIAM RABINOWITZ, *Head of the Department*
201 Social Sciences Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members DiVesta, French, Games, Hall, Hayman, Mitzel, Rabinowitz, Roberts, Seibel, Thevaos, and Withall.

Graduate Faculty: Associate Members Barnette, Schwartz, Snyder, Tjosvold, Weener, and Yesseldyke.

Graduate work is offered in the general field of educational psychology. Students may specialize and do research in school learning, educational and psychological measurement, statistics and research design as applied to education, and the psychology of instructional systems. Other areas of study related to educational psychology, such as counseling and guidance, clinical psychology, and special education, are offered in other departments of the University.

Doctoral degree requirements include a major emphasis in one of the above areas of educational psychology with minor emphasis in one other related area. Typically, the doctoral program of study would include a minimum of one course in each of the following areas: research methods, educational and/or philosophical foundations, computer science, human learning, measurement, social or industrial psychology, experimental psychology, and developmental psychology. In lieu of the foreign language requirement for the Ph.D. degree, it is expected that a student will present to his committee a plan for meeting his objectives, stating his goals and the academic and nonacademic work he expects to undertake in achieving these goals. Within the context of the above, the student will be expected to incorporate relevant experiences which are now part of the language and communication requirements, whether in course work, research, or teaching, to increase his effectiveness as an educational psychologist.

Special facilities include a research design laboratory, a laboratory for computer-assisted instruction, rooms for conducting research projects, facilities for film production and editing, and a closed-circuit television studio used for both research and instruction. Other facilities available to students majoring in educational psychology are the Nursery School, the Psychology Clinic, the Reading Center, the Special Education Center for Children, the Division of Instructional Services, and the Speech and Hearing Clinic. The Computation Center, with several computer systems, is available for use in graduate student research.

Students with a 3.00 junior-senior average and a broad undergraduate background including some college mathematics will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Applicants are required to submit scores on the Graduate Record Examination. Applicants with a master's degree will be required to show more than minimum success in graduate study, including at least one-half of their graduate credits of "A" quality.

EDUCATIONAL PSYCHOLOGY (EDPSY)

400. INTRODUCTION TO STATISTICS IN EDUCATIONAL RESEARCH (3)
406. APPLIED STATISTICAL INFERENCE FOR THE BEHAVIORAL SCIENCES (3)
421. LEARNING PROCESSES IN RELATION TO EDUCATIONAL PRACTICES (3)
450. (Psy. 450) PRINCIPLES OF MEASUREMENT (3)
451. APPRAISAL AND INTERPRETATION OF STANDARDIZED GROUP TESTS (2)
475. INTRODUCTION TO EDUCATIONAL RESEARCH (2)
476. EXPERIMENTATION IN EDUCATIONAL PSYCHOLOGY (3)

501. CURRENT TOPICS IN EDUCATIONAL PSYCHOLOGY (2-6) Study of the current literature in educational psychology with emphasis on historical and theoretical aspects of important areas of investigation. Prerequisites: Ed.Psy. 406, 450, and 421.

506. ADVANCED TECHNIQUES FOR ANALYZING EDUCATIONAL EXPERIMENTS (3) Analytical and experimental control considerations for designs involving nested and/or crossed subjects.

Analysis of variance and multiple comparisons via computers. Prerequisite: Ed.Psy. 406 or Psy. 415.

507. Multivariate Procedures in Educational Research (3) Introduction to matrix algebra, computer programming, multiple regression analysis, multiple and canonical correlation, multiple discriminant analysis, classification procedures, factor analysis. Prerequisite: Ed.Psy. 406 or Psy. 415.

512. Group Processes in the Classroom (2) Basic concepts and perspectives in the study of group processes; instructional group interaction; analysis of classroom behavior.

513. Individual and Group Differences (2) Historical and contemporary attempts to relate individual differences to important social and educational issues. Prerequisite: Ed.Psy. 400 or Psy. 15.

518. Contemporary Learning Models in Educational Psychology (3) Contemporary mathematical models and computer simulations of complex human learning occurring in school settings. Modes for analyzing the learning environment. Prerequisite: Ed.Psy. 421.

519. Psychological Foundations for College Teaching (2) Psychological, sociological and organizational variables which influence college student behavior. Designed for graduate students who anticipate careers in college teaching.

522. Concept Learning in the Schools (2) Study of theory and research related to concept formation and attainment with implications for instruction. Prerequisite: Ed.Psy. 421.

523. Problem Solving in the Schools (2) Examination of theory and research related to cognitive processes in problem solving with implications for educational practice. Prerequisite: Ed.Psy. 421.

524. Theories of Learning and Instruction (3) Study of major classical theories of learning and recent developments in learning and instructional theory. Prerequisite: Ed.Psy. 421.

525. Application of Learning Models to Classroom Practices (2) Probablistic models of acquisition in complex human learning; assessment of learning in the classroom that is amenable to such analysis. Prerequisite: Ed.Psy. 518.

532. Survey of Media Research (3) Systematic study of media research in educational applications of television, still and motion pictures, graphic and simulated environments. Prerequisite: Ed.Psy. 400 or Psy. 415.

550. Design and Construction of Psychological Measures (3) Lecture-practicum involving planning, construction, administration, and analysis of a psychological test; lectures stress construct validity, item analysis, and predictive vaildity. Prerequisite: Ed.Psy. 450.

554. Theories of Psychological Measurement (2) Basic true-score and error models; their extensions to test reliability and test vaildity; problems of item analysis and weighting. Prerequisite: Ed.Psy. 450.

575. Seminar in Educational Psychology (3-9) A seminar dealing with specific topics in educational psychology. Open to advanced students in the behavioral sciences.

591. Problems and Projects in Educational Psychology (1-6) Independent work on special topics.

ELECTRICAL ENGINEERING (E E)

WILLIAM J. ROSS, *Head of the Department*
118 Electrical Engineering East

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Adams, Bredeson, Brown, Cross, Das, Etzweiler, Ferraro, Hale, Lachs, Lee, Lewis, McMurtry, Mentzer, Nisbet, Quinn, Ross, and Volz.

Graduate Faculty: Associate Members Bishop, Carpenter, Delansky, Fonash, Hulina, Jeffreys, Robinson, Stach, and Trutt.

Course offerings and graduate research opportunities are available in the following areas: automatic control, biomedical engineering, computers, electromagnetics, energy conversion, information systems, ionosphere research, networks and circuits, plasmas, quantum electronics, and solid state electronics.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language. The nonthesis option is available for the M.S. degree.

To be admitted to the M.S. program without undergraduate deficiency, a Bachelor of Science degree in Electrical Engineering, or its equivalent, is required with appropriate courses in electrical circuits, fields, and electronics. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 undergraduate grade-point average may be made for students with special backgrounds, abilities, and interests.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 230).

ELECTRICAL ENGINEERING (E E)

401. NETWORK ANALYSIS FOR TECHNOLOGY TEACHERS (3)
402. ELECTRONIC DEVICES AND CIRCUITS FOR TECHNOLOGY TEACHERS, PART I (3)
403. ELECTRONIC DEVICES AND CIRCUITS FOR TECHNOLOGY TEACHERS, PART II (3)
404. ELECTROMECHANICAL ENERGY CONVERSION FOR TECHNOLOGY TEACHERS (3)
405. ELECTRONIC INSTRUMENTATION FOR NONELECTRICAL ENGINEERS AND SCIENTISTS (3)
411. PRINCIPLES OF ELECTROMAGNETIC FIELDS (3)
413. LINEAR NETWORK ANALYSIS (3)
414. PRINCIPLES AND APPLICATIONS OF LASERS AND MASERS (3)
417. SYSTEM THEORY (3)
418. SOLID STATE DEVICE TECHNOLOGY (3)
419. SOLID STATE DEVICES (3)
421a,b,c,d. ELECTRICAL ENGINEERING PROBLEMS (1-10)
423. FUNDAMENTALS OF INDUSTRIAL ELECTRONICS (3)
424. FUNDAMENTALS OF ELECTRICAL DESIGN (3)
425. SYMMETRICAL COMPONENTS (3)
428. LINEAR CONTROL SYSTEMS (3)
432. MICROWAVE METHODS AND ANALYSIS (3)
435. ENGINEERING ANALYSIS (3)
437. ENGINEERING APPLICATIONS OF COMPLEX VARIABLES (3)
438. ANTENNA ENGINEERING (3)
441. ACTIVE CIRCUITS (3)
448. LINEAR ELECTRONIC DESIGN (3)
449. DIGITAL ELECTRONIC DESIGN (3)
450. NETWORK ANALYSIS (3)
459. INTRODUCTION TO STATISTICAL THEORY OF COMMUNICATIONS (3)
461. FUNDAMENTALS OF POWER SYSTEM STABILITY (3)

470. Electronic Analog Computers (3)
471. Logical Design of Switching Systems (3)
472. Introduction to Digital Subsystems (3)
490. (Nuc.E. 490) Introduction to Plasmas (3)
492. (Astro. 492) Space Astronomy and Introduction to Space Science (3)

519. Semiconductor Devices (3) Characteristics and limitations of bipolar transistors, diodes, transit time and bulk-effect devices. Prerequisite: E.E. 419.

521. Advanced Electrical Engineering Problems (1-10)

523. Nonlinear Analysis (3) Transient and steady state analysis of nonlinear physical systems; phase plane analysis, iterative techniques, singular points, and subharmonics. Prerequisite: E.E. 435.

525. Symmetrical Components (3) Polyphase circuits and machines under unbalanced conditions of operation including effects of rotating machines upon distribution and transmission system performance; characteristics of phase converters and single-phase operation of polyphase systems. Prerequisite: E.E. 425.

527. Linear Control Systems (3) Continuous and discrete-time linear control systems; state variable models; analytical design for deterministic and random inputs; time-varying systems stability. Prerequisites: E.E. 428 or M.E. 455; E.E. 417.

528. Nonlinear Control and Stability (3) Design on nonlinear automatic control systems; phase-plane methods; describing functions; optimum switched systems; Liapunov stability; special topics in stability. Prerequisites: E.E. 428 or M.E. 455; E.E. 417.

529. Optimal Control (3) Variational methods in control system design; classical calculus of variations, dynamic programming, maximum principle; optimal digital control systems; state estimation. Prerequisite: E.E. 527.

530. Adaptive and Learning Systems (3) Adaptive and learning control systems; system identification; performance indices; gradient, stochastic approximation, controlled random search methods; introduction to pattern recognition. Prerequisite: E.E. 527.

535. Engineering Analysis (3) Applications of mapping methods, series and integral representations to the solution of boundary value problems in electrical engineering. Prerequisite: E.E. 437.

536. Transform Methods in Linear Analysis (3) Analysis of linear systems by Laplace transform with emphasis on periodic nonsinusoidal forcing functions. Prerequisite: E.E. 435.

538. Electromagnetic Engineering (3) Electromagnetic fields using the Maxwell-Lorentz equations as applied to vector fields, special solutions to scattering, diffraction, and radiation problems. Prerequisite: E.E. 411.

539. Antenna Engineering (3) Boundary value problems of radiating structures, integral equation formulations, source excitation problems, reflector antennas. Prerequisites: E.E. 411, 438.

540. (Nuc.E. 540) Theory of Plasma Waves (3) Solutions of the Boltzmann equation; waves in bounded and unbounded plasmas; radiation and scattering from plasmas. Prerequisite: E.E. 490.

541. (Nuc.E. 541) Plasma Theory (3) Advanced topics in kinetic theory, fluctuation theory, microinstability, and turbulence. Prerequisite: E.E. 540 (Nuc.E. 540).

546. Field-Effect Devices (3) The physical background, characteristics and limitations of surface field-effect and junction field-effect devices and related structures. Prerequisite: E.E. 419.

547. Dielectric Devices (3) Applications of insulator physics and devices based on insulator properties. Prerequisite: E.E. 419.

548. Linear Integrated Circuits (3) Design of monolithic, thin-film and hybrid linear integrated circuits; D.C., video, tuned, r.f. and microwave applications. Emphasis on reliability. Prerequisites: E.E. 418, 448.

550. Network Synthesis (3) Positive real functions, realizability conditions, synthesis of driving point immittances, synthesis of two-terminal pair networks, transfer function synthesis. Prerequisites: E.E. 437, 450.

560. Statistical Theory of Communications (3) Generalized harmonic analysis; the application of correlation and convolution to the detection of signals in noise; various special topics. Prerequisite: E.E. 459 or Math. 409.

561. Information Theory (3) Mathematical measurement of information; information transfer in discrete systems; redundancy, efficiency, and channel capacity; encoding systems. Prerequisite: E.E. 459 or Math. 409.

562. Detection Theory (3) Detection decision theory, Bayes and Neyman-Pearson criteria, optimal receivers, classical estimation theory, signal-noise representations, optimum linear signal parameters estimation. Prerequisite: E.E. 560.

566. (Cmp.Sc. 566) Algebraic Coding Theory (3) Polynomial rings, galois fields, linear codes, cyclic codes, BCH codes, finite projective geometry cyclic codes, convolution codes, graph theoretic codes. Prerequisite: Cmp.Sc. 450 or E.E. 561.

569. Simulation of Biomedical Systems (3) Simulation of biological and medical systems on analog and digital computers; direct electrical analogs; modeling techniques. Prerequisites: E.E. 470 or Cmp.Sc. 401; Biol. 11.

570. Advanced Electronic Analog Computers (3) Advanced techniques of analog computation and simulation; machine and problem errors; nonlinear differential equations. Prerequisite: E.E. 470.

571. Digital Computers: Recent Developments and Advanced Logic (3) Advanced treatment of logical design; discussion of topics of current interest in the general area of digital computers. Prerequisite: E.E. 471.

572. Digital System Design (3) Complete digital system design including specification, internal organization, and realization. Discussion of interaction among digital systems and subsystems. Prerequisite: E.E. 472.

580. Radio Waves and the Ionosphere (3) The magneto-ionic theory of ionospheric wave propagation; ray-optical approximations; determination of ionization profiles; full wave solutions; nonlinear and coupling effects. Prerequisite: E.E. 62 or 438 or Phys. 557.

581. Constitution of the Ionosphere (3) Properties of neutral and ionized atmosphere above 60 km; photochemical processes; solar, meteoric perturbations of the ionosphere; large-scale movements in ionization.

ELEMENTARY EDUCATION (EL ED)

Robert Lesniak, *In Charge of Graduate Program*
The Capitol Campus, Middletown, Pa. 17057

Degree Conferred: M.Ed.

Graduate Faculty: Senior Member Lear.

Graduate Faculty: Associate Members Alexander, Allison, Ammon, Barnes, Eisenstein, Lesniak, Miller, Ongiri, Smith, Starkey, Sullivan, Swetz, Verma, and Zoldos.

The aim of the program is to provide advanced professional study for experienced teachers who wish to improve their knowledge and skills in the classroom and education-related situations.

Individual programs of study may be built with concentrations in the particular subject areas of elementary school curriculum, early childhood, and urban education.

A total of 36 credits is normally required, including at least 12 credits in the 500 series; from one-third to two-thirds of credit work should be in courses other than education courses. An original master's paper or creative production is required.

Students who have graduated from an accredited institution with a 2.50 junior-senior average will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum grade-point average may be made for students with special backgrounds, abilities, and interests. The application and transcript should be sent directly to the Graduate Office, The Capitol Campus, Middletown, Pa. 17057.

ENGINEERING ACOUSTICS (E ACS)

JIRI TICHY, *Chairman of the Committee on Engineering Acoustics*
Applied Research Laboratory, Applied Science Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Arndt, Baker, Brown, Brubaker, Hayek, Johnson, Martin, Michael, Neubert, Pigott, Reethof, Rowlands, Skudrzyk, Snowdon, and Tichy.

Graduate Faculty: Associate Members Ackerman, Farwell, George, King, Lawther, Macaluso, Miller, Prout, Sibul, Thompson, and Watson.

The aim of this intercollege program is to enable the student interested in acoustics to obtain an integrated program of courses covering the fundamentals of acoustical science and the biological, communications, and engineering applications of acoustics.

Programs are arranged through a selection of appropriate courses offered by several departments in the Colleges of Science, Engineering, Education, and Arts and Architecture, as well as those specifically in the area of engineering acoustics.

Areas of concentration include acoustic signal processing, architectural and building acoustics, noise and vibration, physical acoustics, speech and hearing, and underwater acoustics. Thesis research in the various areas may be conducted in relevant departments and in the Applied Research Laboratory.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by competence in the use of computer language as well as a reading knowledge of a foreign language.

Entering students should hold a bachelor's degree in physics, biology, engineering, architecture, mathematics, psychology, speech and hearing, or in a closely related field; and they should have had at least one year of physics and mathematics including integral calculus. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

In addition to the engineering acoustics courses listed below, the following courses on acoustics and closely related areas are available: Aersp. 412, 444, 506, 511, 515, 516, 517; A.E. 442, 458, 542; E.E. 459, 560, 561, 562; E. Mch. 401, 412, 522, 524A,B, 525, 527, 528, 550, 570, 597; M.E. 458; Phys. 443, 533; Spch. 431; S.P.A. 434, 531, 532, 534.

ENGINEERING ACOUSTICS (E ACS)

401. GENERAL ACOUSTICS (3)

500. Special Problems in Acoustics (1-6) Provides training in selected areas of acoustics by means of supervised investigations or studies. Prerequisite: Phys. 443.

501. Engineering Acoustics Seminar (1 per term) Recent developments and current research in engineering acoustics.

511. Underwater Sound Propagation (3) Theoretical and empirical treatment of sound propagation in the ocean, including effects of the environment, characteristics of targets, and transducers.

512. Sonar Engineering (3) Theoretical and empirical treatment of problems related to the use of underwater sound in target detection and ranging.

513. Modern Acoustic Signal Processing (3) Probability review, representation of signals, noise processes, optimum filtering, ambiguity functions, linear and nonlinear signal processing, application to sonar systems.

514. Electroacoustic Transducers (3) The theory, design, and calibration of passive, linear, reciprocal electroacoustic transducers for use in both air and water media. Prerequisite: Phys. 443.

515. Acoustics in Fluid Media (3) Wave propagation in stationary and moving fluids; acoustic radiation and scattering; standing waves in ducts and cavities. Prerequisites: E.Mch. 524A, Phys. 443.

ENGINEERING MECHANICS (E MCH)

John R. Mentzer, *Acting Head of the Department of Engineering Science and Mechanics*
227B Hammond Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Davids, Hardenbergh, Hayek, Haythornthwaite, Hu, Kiusalaas, Mentzer, Neubert, Sharma, and Zamrik.

Graduate Faculty: Associate Members Conway, Fonash, Kimmel, Llorens, MacDonald, Queeney, and Thompson.

Graduate study is available in the following areas: (1) dynamics, including mechanics of rigid bodies, vibration, and stress waves; (2) mechanics of deformable bodies including elasticity, plasticity, viscoelasticity, and continuum mechanics; (3) mechanics of materials and structures including mechanical properties, plates and shells, and plastic analysis; (4) experimental mechanics including experimental stress analysis, photoelasticity, and experimental vibration.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

The entering student must hold a bachelor's degree in engineering or science and have satisfactorily completed undergraduate courses in mechanics. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

ENGINEERING MECHANICS (E MCH)

400. Advanced Strength of Materials (3) *Mr. Hu*
401. Elements of Vibrations (3) *Mr. Davids*
402. Applied and Experimental Stress Analysis (3) *Mr. Conway*
403. Mechanics of the Solid State (4) *Mr. Queeney*
404. Research in Engineering Mechanics (1-6) *Mr. Conway*
407. Elements of Computer Methods in Engineering (3) *Mr. Hardenbergh*

408. Elasticity and Engineering Applications (3) *Mr. Kiusalaas*
409. Advanced Mechanics (3) *Mr. Hardenbergh*
410. Mechanics of Space Flight (3) *Mr. Hardenbergh*
412. Experimental Methods in Vibrations (3) *Mr. Neubert*
413. Plastic Analysis of Structures (3) *Mr. Haythornthwaite*
414. Elements of Material Science (3) *Mr. Kimmel*
421. Continuum Mechanics (3) *Messrs. Hu and Pytel*
422. Continuum Mechanics (3) *Mr. Hu*
446 Mechanics of Viscoelastic Materials (3) *Mr. Sharma*

500. Advanced Mechanics of Materials (3-6) Strain energy methods; special problems in bending and torsion; curved bars, beams on elastic foundations; thick-walled cylinders, shrink-fit assemblies, and rotating discs; thin-walled pressure vessels; bending of thin plates; buckling of bars and plates. Prerequisite: E.Mch. 13. *Mr. Zamrik*

506. Experimental Stress Analysis (3) Experimental methods of stress determination including photoelasticity, stress coat and electric strain gauge techniques; stress analogies; strain rosettes for combined stress determinations. Prerequisite: E.Mch. 408 or 507. *Mr. Conway*

507. Theory of Elasticity and Applications (3) Equations of equilibrium and compatibility; stresses and strains in beams, curved members, rotating discs, thick cylinders, torsion and structural members. Prerequisite: E.Mch. 13. *Mr. Kiusalaas*

508. Theory of Elastic Stability and Applications (3) Buckling of slender and short members; buckling of I-beams; stability of thin-walled constructions; thin-walled cylinders subjected to external pressures; applications to structural parts including aircraft members. Prerequisites: E.Mch. 12, 13. *Mr. Kiusalaas*

509. Theory of Plates and Shells (3) Bending and buckling of plates; elastic foundations; deformation of shells, multilayer shells, stress and stability analysis, weight optimization, application problems. Prerequisite: E.Mch. 13. *Mr. Kiusalaas*

514. Engineering Mechanics Seminar (1 per term) Current literature and special problems in engineering mechanics.

516. Mathematical Theory of Elasticity (3) Fundamental equations and problems of elasticity theory; uniqueness theorems and variational principles; methods of stress functions and displacement potential; applications. Prerequisite: E.Mch. 540. *Mr. Hayek*

520. Advanced Dynamics (3) Dynamics of a particle and of rigid bodies: Newtonian equations in moving coordinate systems; Lagrange's and Hamilton's equations of motion; special problems in vibrations and dynamics. Prerequisites: E.Mch. 12; Math. 72 or 431. *Mr. Kiusalaas*

521. Stress Waves in Solids (3) Theoretical fundamentals, classic experiments; recent advances, including scabbing applications, plastic waves, penetration mechanics, impact and numerical methods. Prerequisites: E.Mch. 12; Math. 405 or E.Mch. 524. *Mr. Davids*

522. Theory of Vibrations (3) Mathematical theory of vibrating systems; damping phenomena; forced vibrations; analogy between mechanical and electrical vibrations; transverse and torsional oscillation of shafts; vibration of strings, beams, membranes, and plates. Prerequisites: E.Mch. 13; Math. 72 or 431. *Mr. Neubert*

523. Computer Methods in Engineering Analysis (3) Finite elements, finite differences, and matrix methods applied to dynamics, elasticity, wave propagation, heat conduction structural analysis, and fluid flow. Prerequisites: Cmp.Sc. 401, Math. 72. *Mr. Davids*

524. Mathematical Methods in Engineering (3 per unit) Prerequisite: A.M. 451 or E.E. 435 or M.E. 452. *Messrs. Hayek and Thompson*

Unit A (3) Basic tools, including Fourier, Legendre, and other orthogonal series, special functions, Laplace transforms. Applications in mechanics and other fields. Prerequisite: Math. 73.

Unit B (3) Solution techniques for boundary-value problems in curvilinear coordinates, integral transforms. Green's functions, potentials, applications to diffusion, vibration, wave-propagation. Prerequisite: E.Mch. 524A or Math. 431.

525. Vibration and Shock in Damped Mechanical Systems (3) Rubberlike materials; vibration isolation; structural impedance; wave propagation; multiforce excitation of beams; Timoshenko beams; transients; shock spectra; damage; nonlinear response. Prerequisite: E.Mch. 401 or 522. *Mr. Snowden*

526. Nonlinear Mechanics (3) Integral curves, singular points, self-sustained oscillations, stability problems, Hill's and Van der Pol's equation, mechanical and electrical application. Prerequisite: E.Mch. 522. *Mr. Neubert*

527. Structural Dynamics (3) Dynamic behavior of structural systems; normal modes; input spectra; finite element representation of frameworks, plates, and shells; impedance; elastic-plastic response. Prerequisites: E.Mch. 12, 13. *Mr. Neubert*

528. Experimental Methods in Vibrations (3) Investigation of one or more degrees of freedom, free and forced mechanical vibrations, vibration properties of materials, nondestructive testing. Prerequisite: E.Mch. 401 or 522. *Mr. Neubert*

530. Solid State Mechanics (3) Relation between solid state physics and mechanics; mechanical properties for static, fatigue, creep, and impact conditions; high temperature properties; applications. Prerequisite: E.Mch. 14. *Mr. Hu*

531. Theory of Plasticity and Applications (3) Yield condition; plastic stress-strain relations; theory of slip-line fields; applications to bending, torsion, axially symmetric bodies, metal processing. Prerequisite: E.Mch. 507. *Mr. Hu*

533. Determination of Mechanical Properties (3) Experimental methods for determining hardness, elastic constants, creep behavior, fatigue strength, plastic flow, and dynamic properties of metals. Prerequisite: E.Mch. 14 or 530. *Mr. Zamrik*

534. Photoelasticity (3) Analysis of polariscopes; isoclinics, isochromatics, and stress trajectories; two- and three-dimensional photoelastic methods; determination of principal stresses; model preparation. Prerequisite: E.Mch. 408 or 507. *Mr. Conway*

535. (Metal. 535) Crystal Defects and Mechanical Response (3) Mechanical responses of crystalline solids containing point, line, and interfacial defects; elastic and plastic responses. Prerequisite: Metal. 514 or E.Mch. 414. *Mr. Queeney*

540. Introduction to Continuum Mechanics (3) Algebra and analysis of tensors; balance equations of classical physics; the linear theories of continuum mechanics. *Mr. Hayek*

541. Nonlinear Theories of Continuum Mechanics (3) The general theory of constitutive equations; finite deformations and elasticity; flow and fluidity; viscoelasticity, modern topics. Prerequisite: E.Mch. 540. *Mr. Hayek*

546. Theory of Viscoelasticity and Applications (3) Linear and nonlinear viscoelastic theories; generalized isotropic and anisotropic viscoelastic stress-strain relations. Prerequisite: E.Mch. 507. *Mr. Sharma*

550. Studies in Engineering Mechanics (1-6) Studies in any field of engineering mechanics.

570. Random Vibrations in Structural Mechanics (3) Probability theory applied to random vibrations of linear and nonlinear systems; excitation by ground motion, turbulence, and noise; acoustic damping. Prerequisite: Aersp. 411 or E.Mch. 401 or 522. *Mr. Neubert*

597. Special Topics (1-6)

ENGINEERING SCIENCE (E SC)

LESLIE C. HALE, *Chairman of the Engineering Graduate Committee for Off-Campus Programs*
303 Electrical Engineering East

Degree Conferred: M.Eng.

A program leading to the degree of Master of Engineering with a major in engineering science is offered at the Behrend and King of Prussia Graduate Centers and at the Capitol Campus near Harrisburg. Details of the program may be obtained by writing directly to these locations. Addresses are given in the front of this bulletin.

The program is designed to provide a broad, advanced education in the engineering sciences with some specialization permitted in the area of the student's major interest. It is offered specifically to permit practicing engineers to pursue advanced studies through evening classes while in full-time employment in industry in the area. Courses offered for the program are all established and controlled by the resident departments at the University Park Campus.

The credit requirements in this major will be satisfied by an appropriate combination of core courses and elective courses. The core courses include offerings in mathematics and in several branches of engineering which have been selected because of their general character and breadth of applicability to all fields of engineering.

A minimum of 33 credits is required of which at least 12 must be at the 500 level. A scholarly written report is also required. Three of the above credits may be applied to this report.

Students may be admitted to the program from a wide variety of disciplines. Students applying for admission are expected to have completed the following core of previous student experience: (1) physics through modern physics, (2) mathematics through differential equations, (3) one course in engineering thermodynamics, (4) one course in electrical circuits, and (5) basic courses in engineering statics and dynamics. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Further details regarding admission requirements are available from the directors of the graduate campuses offering the program.

ENGLISH (ENGL)

ARTHUR O. LEWIS, JR., *Acting Head of the Department*
117 Burrowes Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty: Senior Members Austin, Begnal, Condee, Frank, Jewkes, Lewis, Meserole, Price, Reed, Rosenberg, Rubin, Sams, Stewart, Weintraub, West, and Young.

Graduate Faculty: Associate Members Arnold, Borklund, Buckalew, Crane, Damerst, Eckhardt, Fitzgerald, Gidez, Grecco, Hudspeth, Joukovsky, Kiernan, Lougy, Mann, McAdams, Rodgers, Rogers, Secor, Shedd, Smith, and Walden.

A student may specialize in English literature, American literature, or philology. It is preferred that an entering student present 24 credits in English, but 18 credits in English exclusive of survey and freshman courses will be accepted. If the student does not present 18 credits in English, he must make up the deficiency early in his graduate work. A thesis is required of all M.A. candidates in this major.

The communication and foreign language requirement for the Ph.D. degree may be met by successful performance in any one of the following options: (1) critical and scholarly competence in one area of the literature of a foreign language; (2) reading, writing, and speaking

knowledge of one foreign language; (3) reading knowledge of two foreign languages; or (4) reading knowledge of one foreign language and demonstrated competence (normally by successful course work) in a technique such as computer science, statistics, etc., where relevant to the student's research interest.

Students with a 3.30 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.30 grade-point average may be made for students with special backgrounds, abilities, and interests.

ENGLISH (ENGL)

406. History of the English Language (3) *Messrs. Buckalew, Crane, Moore, Rosenberg, and Shedd*
407. History of the English Language for Teachers (3) *Messrs. Buckalew, Moore, Rosenberg, and Shedd*
408. Applied English Language Analysis (3) *Mr. Kiffer*
411. Problems of Style (3)
412. The Writing of Fiction (3-6) *Messrs. Klass, Rogers, Rubinstein, and West*
413. Verse Writing (3-6) *Mr. Haag*
414. Biographical Writing (3) *Mr. Weintraub*
415. Nonfictional Writing (3) *Mr. Klass*
418. Advanced Technical Writing and Editing (3-6) *Mrs. Eckhardt, Messrs. Damerst and Holahan*
422. Studies in British Literature (3-6) *Staff*
432. Masters of American Literature (3-6) *Staff*
434. Movements in American Literature (3-6) *Staff*
435. The American Short Story (3) *Messrs. Hudspeth, Levy, and Schneeman*
437. American Poetry (3) *Messrs. Gidez and Rubin*
438. American Drama (3) *Mr. Grecco*
441. Poetry and Prose of the Early Seventeenth Century (3) *Messrs. Arnold, Condee, and Kiernan*
442. Poetry and Prose of the Late Seventeenth Century (3) *Mr. McAdams*
444. Shakespeare: The Genres (3) *Staff*
445. Chaucer (3) *Staff*
446. Milton (3) *Messrs. Condee, McAdams, and Moore*
447. The Elizabethan Renaissance (3) *Messrs. Moore, Price, and Reed*
448. Shakespeare's Contemporaries (3) *Messrs. Arnold, Jewkes, Kiernan, and Moore*
450. Readings in English (1-6) *Staff*
451. The Augustans (3) *Messrs. Buck and Fitzgerald*
452. The Age of Johnson (3) *Messrs. Buck and Fitzgerald*
455. The Novel in England to Jane Austen (3) *Messrs. Buck, Fitzgerald, and Joukovsky*
458. Restoration and Eighteenth-Century Drama (3) *Mr. Rogers*
461. British Thought of the Nineteenth Century (3) *Miss Austin, Messrs. Goodwin and Lougy*
462. Wordsworth and Coleridge (3) *Mr. Lougy*
463. Byron, Shelley, and Keats (3) *Miss Austin*
465. Victorian Novel (3) *Miss Austin, Messrs. Goodwin and Lougy*
466. The American Novel to 1900 (3) *Messrs. Gidez and Secor*
467. Victorian Poetry (3) *Miss Austin, Messrs. Goodwin and Lougy*
470. Literature of the British Commonwealth (3) *Mr. Mann*
475. Modern British Fiction (3) *Messrs. Crane, Maxwell, Smith, and West*
476. The American Novel Since 1900 (3) *Mr. Young*
477. Modern Poetry (3) *Mrs. Rodgers, Messrs. Haag and O'Donnell*
478. British and Irish Drama Since 1890 (3) *Messrs. Grecco and O'Donnell*
481. History of English Literary Criticism (3) *Messrs. Borklund and Stewart*
488. (C.Lit. 488) Modern Continental Drama (3) *Mr. Grecco*
490. Rhetorical Theory and Practice (3) *Mrs. Ebbitt, Messrs. Holahan and Rubinstein*

491. Literature for Teachers in Secondary Schools (3) *Messrs. Goodwin and Knapp*
496. The Folktale in American Literature (3) *Mr. Rosenberg*
*498. English Institute (6-12)

501. Materials and Methods of Research (4) Materials and techniques of research in English and American literary history; form and content of theses. Required of all graduate students with an English major. *Messrs. Joukovsky, Mann, and Meserole*

520. The Middle English Romance (3) A detailed study of the Middle English metrical romance in terms of its milieu and its genre in the West. *Mr. Rosenberg*

521. Old English Language (3) An introduction to the main features of the Old English language; readings in simple Old English prose and poetry. *Mr. Buckalew*

522. Beowulf (3) Reading and critical analysis. Prerequisite: Engl. 521. *Mr. Buckalew*

523. Wordsworth and Coleridge (3) Major and some minor works; the pertinent criticism and scholarship; aspects of the period.

524. Byron and Shelley (3) Major and some minor works; the pertinent criticism and scholarship; aspects of the period. *Miss Austin*

525. Blake and Keats (3) Major and some minor works; the pertinent criticism and scholarship; aspects of the period. *Miss Austin*

526. Tennyson and Browning (3) *Mr. Lougy*

536. Henry James (3) The development of James as critic, novelist, and short story writer. *Mr. Borklund*

540. Studies in Elizabethan Prose and Poetry (3-6) *Messrs. Price and Reed*

541. Medieval Studies (3-6) Special problems in medieval English literature. *Messrs. Frank and Rosenberg*

542. Middle English Literature (3) Introduction to Middle English and its dialects; study of the literature of the period exclusive of Chaucer. *Messrs. Buckalew, Frank, and Shedd*

543. Studies in Early Seventeenth-Century Literature (3-6) Major poets and prose writers from 1600 to 1660. *Mr. Condee*

544. Restoration Literature (3) Selected studies of writers in England between 1650 and 1700. *Mr. Fitzgerald*

545. Chaucer (3-6) Critical study of the *Canterbury Tales* or *Troilus and Criseyde* and minor poems. *Messrs. Frank, Rosenberg, and Shedd*

546. Milton (3) The poetry and prose of John Milton. *Mr. Condee*

548. Elizabethan and Jacobean Drama (3-6) English drama from 1558 to 1642 exclusive of Shakespeare. *Messrs. Arnold and Jewkes*

549. Shakespeare (3-6) Special problems of sources, chronology, text, characterization, and motivation in the drama. *Messrs. Jewkes, Price, and Reed*

552. Swift and Pope (3) *Mr. Sams*

553. The Age of Johnson (3) The work of Johnson and his circle. *Mr. Fitzgerald*

554. Studies in Early American Literature (3) *Mr. Meserole*

556. Eighteenth-Century British Fiction (3) *Messrs. Fitzgerald and Sams*

557. Early Eighteenth-Century British Literature (3) Prose and poetry in the reign of Queen Anne, with special attention to periodical publications. *Mr. Sams*

560. American Romanticism (3) The Romantic movement in American literature of the mid-nineteenth century. *Messrs. Hudspeth and Secor*

561. Studies in the Romantic Movement (3-6) *Miss Austin and Mr. Jewkes*

562. Studies in the Literature of Victorian England (3-6) *Miss Austin and Mr. Weintraub*

*A maximum of 6 credits in one summer.

564. STUDIES IN NINETEENTH-CENTURY AMERICAN LITERATURE (3) The major figures treated will vary from year to year. *Messrs. Gidez, Hudspeth, Rubin, and Secor*

573. STUDIES IN TWENTIETH-CENTURY BRITISH LITERATURE (3-6) Major writers and literary movements. *Messrs. Begnal, Crane, Weintraub, and West*

574. STUDIES IN TWENTIETH-CENTURY AMERICAN LITERATURE (3-6) Major writers and literary movements.

575. JAMES JOYCE (3-6) Alternate terms: *Ulysses* and *Finnegans Wake.* Knowledge of *Dubliners* and *A Portrait of the Artist* is assumed. *Mr. Begnal*

576. HEMINGWAY AND FAULKNER (3) The major works. *Messrs. Crane and Young*

578. SHAW (3) The plays, prose writings, and literary influence of G.B.S. *Mr. Weintraub*

579. T. S. ELIOT (3) Major works in poetry, criticism, and drama; pertinent scholarship and criticism. *Mrs. Rodgers*

581. CONTEMPORARY LITERARY CRITICISM (3) *Messrs. Borklund, Sams, and Stewart*

582. HAWTHORNE AND MELVILLE (3) Detailed study of the major works of both authors and of the relationship between the two men. *Messrs. Gidez and Young*

583. EMERSON AND THOREAU (3) The significant prose and poetry of the chief American transcendentalists. *Mr. Hudspeth*

584. WHITMAN AND DICKINSON (3) The major texts, with special emphasis on background and language. *Messrs. Rubin and Secor*

586. READINGS IN LITERATURE (1-12) Programs of readings designed to meet specific needs of individual students. *Staff*

587. FRANKLIN AND EDWARDS (3) Studies in the lives, works, and milieu. *Mr. Meserole*

588. STUDIES IN AMERICAN FICTION (3-6) *Messrs. Gidez, Hudspeth, Rubin, and Secor*

589. STUDIES IN AMERICAN POETRY (3-6) *Mrs. Rodgers, Messrs. Borklund and Rubin*

592. STUDIES IN AMERICAN LITERARY MYTH (3) An introduction to an interpretive, interdisciplinary study of some representative themes in American literature and culture. *Mr. Young*

593. (C.Lit. 593) ANGLO-AMERICAN FOLK SONG (3) Survey of relevant literary and ethnological scholarship and field work, European and American, from the early sixteenth century to the present.

595. STUDIES IN BRITISH FICTION (3-6) *Messrs. Crane and West*

ENTOMOLOGY (ENT)

BECKFORD F. COON, *Head of the Department*
102 Patterson Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members Asquith, Benton, Coon, Ercegovich, Hower, Kim, Mumma, Rutschky, Smyth, Snetsinger, and Yendol.

Graduate Faculty: Associate Members Byers, Jubb, and Smilowitz.

A student majoring in entomology may specialize in various areas of economic entomology and in forest entomology, apiculture, insect resistance in plants, arachnology, medical or veterinary entomology, biological control, insect pathology, insect transmission of plant pathogens, ecology, morphology, embryology, taxonomy, physiology, insect behavior, or chemistry of pesticides.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by one foreign language and proficiency in English.

For admission a student is required to have 24 credits in entomology and related biological and physical sciences. Chemistry through organic, physics, mathematics, and statistics are advantageous. A limited deficiency may be made up, without degree credit, while pursuing graduate work.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

ENTOMOLOGY (ENT)

401. Medical and Veterinary Entomology (3) *Mr. Kim*
409. Insect Biology and Management (3) *Mr. Rutschky*
412. Field Entomology (3) *Mr. Rutschky*
414. Insect Morphology and Phylogeny (3) *Messrs. Kim and Rutschky*
415. Insect Physiology and Biochemistry (3) *Messrs. Mumma and Smyth*
416. Insect Ecology and Control (3) *Messrs. Cameron and Hower*
418. Forest Entomology (3) *Mr. Cameron*
425. Freshwater Entomology (3) *Mr. Kim*
431. Special Problems (1-6)
435. Arachnology (3) *Mr. Snetsinger*

515. Insect Morphology and Systematics (1-3) Current theories, controversies and advanced techniques in comparative morphology, histology, embryonic and postembryonic development, taxonomy and systematics of insects. Winter term.

516. Insect Physiology and Biochemistry (1-3) Selected topics in insect function and metabolism. Fall term.

517. Insect Ecology and Behavior (1-3) Selected aspects of the biotic and abiotic interactions of insects. Winter term.

518. Pest Management (1-3) Current concepts and controversies in modern agricultural and urban pest management practice. Spring term.

531. Insect Toxicology (2) General principles of toxicology and survey of the actions of substances toxic to insects. Fall term, odd years.

532. Insect Behavior (2) Orientation reflexes, learning, communication, and social behavior; physiological bases, ecological and evolutionary implications. Summer term, odd years.

535. Biological Control (3) Practical and theoretical aspects of arthropod control by entomophagous insects and the place of biocontrol in integrated control programs. Winter term, even years.

536. Insect Pathology (3) Diseases of arthropods and some aspects of microbial control of insects. Prerequisite: Micrb. 1. Winter term, odd years.

542. (Biol. 542) Systematics (3) Principles and methods of classification, phylogeny and speciation; taxonomic techniques; analysis of species, causal interpretation of animal diversity. Fall term.

590. Colloquium (1-3)

596. Individual Studies (1-6)

597. Special Topics (1-6)

ENVIRONMENTAL POLLUTION CONTROL (E P C)

WILLIAM J. MOROZ, *In Charge of Graduate Programs in Environmental Pollution Control*
226 Merrell R. Fenske Laboratory

Degrees Conferred: M.S., M.Eng., M.E.P.C.

Graduate Faculty: Senior Members Aplan, Eagleton, Heicklen, Hunt, Langmuir, Moroz, Nesbitt, and Watrous.

This intercollege program deals with the various aspects of the control of air and water pollution and the disposal of solid wastes. Graduate instruction is under the direction of an interdisciplinary faculty committee and the departments participating in the program. The faculty consists of the committee members listed above and a larger group of graduate faculty members with a teaching and/or research interest in the area of environmental pollution control.

Students are required to pass 9 credits of core courses: C.E. 472, Water Pollution Control; C.E. 476, Solid Waste Management; and M.E. 470, Introduction to Air Pollution Control. In addition, they must select at least 21 of their total credits from a recommended course list and schedule the environmental pollution control seminars (590) for three terms. A thesis is optional. If the option to prepare a thesis is selected, the topic must be in the area of environmental pollution control and at least 6 credits of research must be taken in the department with which the student is affiliated.

Admission to the program will be granted upon recommendation of the academic department in which the student plans to follow his studies and the Environmental Pollution Control Program Faculty Committee. Normal admission requirements include mathematics through integral calculus plus one year's work in general physics and chemistry. Students with a 2.75 junior-senior average and with appropriate backgrounds in mathematics and science will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.75 grade-point average may be made for students with special backgrounds, abilities, and interests. Entering graduate students for whom English is not the first language are required to have a score of at least 550 on the TOEFL (Test of English as a Foreign Language) examination.

ENVIRONMENTAL POLLUTION CONTROL (E P C)

590. COLLOQUIUM (1-3)

EXTENSION EDUCATION (EXTED)

DARYL K. HEASLEY, *Acting Chairman of the Committee on Extension Education*
204 Weaver Building

Degrees Conferred: M.Agr., M.Ed.

This program is designed primarily to meet the needs of professional teachers in various extension and adult education positions. The purpose is to train individuals to develop attitudes, understandings, and competences which enable them to become more effective professional workers. Options have been developed for the College of Agriculture. Additional options will be offered as they are developed by other Colleges.

For either degree a minimum of 30 credits is required, including a professional paper. These credits should be distributed as follows: 12 credits in extension core courses, 6 in communication and/or education, and 12 in two areas of agriculture and/or home economics.

Admission requirements include a strong background in agriculture or home economics and a minimum of 12 credits in the social sciences. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students.

Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

FOOD SCIENCE (FD SC)

DONALD V. JOSEPHSON, *Chairman of the Division of Food Science and Industry*
111 Borland Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Dimick, Josephson, Keeney, Kroger, MacNeil, McArdle, McCarthy, Patton, Sink, Thompson, Watrous, and Ziegler.

Graduate Faculty: Associate Members Beelman, Glass, Kuhn, and Ostovar.

Opportunities are available for study in the fields of dairy products, meats, fruits and vegetables, and poultry products. Special emphasis can be devoted to food chemistry, microbiology, quality control, flavor control and acceptance, rheology, processing, packaging, and distribution.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language or through completion of 9 credits of course work in a specialized area approved by the student's advisory committee.

Prerequisite to graduate work is the completion of an undergraduate degree in food science, biochemistry, microbiology, or another related area. The undergraduate program must include calculus, organic chemistry, microbiology, and general physics. Students may be admitted with deficiencies but are required to make them up without degree credit. Students who present a 2.75 junior-senior average will be considered for admission to the program subject to the limitations of the physical facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

FOOD SCIENCE (FD SC)

400. EFFECTS OF PROCESSING ON FOODS (3)
403. SANITATION AND QUALITY CONTROL (3)
404. SENSORY EVALUATION OF FOODS (2)
410. CHEMICAL METHODS OF FOOD ANALYSIS (4)
421. TECHNICAL CONTROL PROBLEMS (1-6)

505. CONCEPTS OF PRODUCT DEVELOPMENT (3) Interrelationships of processing principles and chemical and physical properties in the development of new and improved food products.

507. FOOD QUALITY, FOOD STANDARDS, AND CONSUMER PROTECTION (2) Problems of the food industry relating to contamination and quality of food products.

510. SEMINAR IN FOOD SCIENCE (1-6)

520. PROBLEMS IN FOOD SCIENCE (1-9) Special problems in dairy, horticultural, meat, poultry, and other food products.

522. RESEARCH PROCEDURES IN FOOD SCIENCE (3) Research problems and methods in food science with major emphasis on food chemistry.

In addition to the courses listed above, the following courses are available in food science; their descriptions may be found under the offerings of the cooperating departments: A.I. 421, 431, 502; Ag.E. 412, 413, 414, 423, 503; D.Sc. 427, 521; Hort. 528; Micrb. 414; Pty.Sc. 504.

FOREST RESOURCES (FOR R)

WILBER W. WARD, *Director of the School of Forest Resources*
101 Ferguson Building

Degrees Conferred: Ph.D., M.S., M.F.

Graduate Faculty: Senior Members Beall, Borden, Fletcher, George, Gerhold, Hutnik, Lindzey, Murphey, Shipman, Sopper, and Ward.

Graduate Faculty: Associate Members Anthony, Baldwin, DeWalle, Kersavage, Storm, and Turner.

The Doctor of Philosophy and the Master of Science degree programs are oriented toward research, education, and scientific technology in the professions of forestry, wildlife management, and wood science. The foreign language requirement for the Ph.D. degree may be satisfied by demonstrating competence in one foreign language equivalent to passing three college-level courses.

The Master of Forestry is a professional degree which emphasizes application of knowledge through managerial practices involving forest resources, industries, or the natural environments of communities and recreational areas.

A thesis is required for each of the degrees. Most programs of study are strengthened by including appropriate courses offered by related departments.

Faculty expertise, laboratories, and outdoor research facilities are available to support specialization in a variety of fields. Possibilities for specialization are indicated in part by the courses listed under forestry, wood science, and wildlife; also by related courses in agricultural economics, agronomy, animal nutrition, biology, business administration, chemical engineering, computer science, ecology, economics, entomology, environmental pollution control, environmental resource management, genetics, horticulture, industrial engineering, landscape architecture, meteorology, physiology, plant pathology, polymer sciences, recreation and parks, regional planning, or statistics.

To be considered for admission a student should have at least a 2.50 all-university average and 9 credits of basic biology; 12 credits of calculus, statistics, and computer science; 12 credits of chemistry and physics; 12 credits of communications; 12 credits of economics and social sciences or humanities; and 18 credits in forestry, wildlife, or wood science. Each applicant should arrange for three reference report forms to be sent and should submit a brief statement describing his academic goals, career interests, and special qualifications for proposed studies. The best-qualified applicants will be accepted up to the number of spaces available. Exceptions to the 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 230).

FORESTRY (FOR)

403. DENDROLOGY (3)
410. FOREST RESOURCES SEMINAR (1)
416. FOREST RECREATION (3)
421. SILVICULTURE (3)
427. FOREST RANGE MANAGEMENT (3)
440. FOREST ECONOMICS AND FINANCE (3)
450. INTRODUCTION TO OPERATIONS RESEARCH (3)
455. AERIAL PHOTOS IN FORESTRY (3)
466. FOREST RESOURCE MANAGEMENT (3)
480. POLICY AND ADMINISTRATION (3)
497. PROBLEMS IN FORESTRY (1-6 per term)

508. Forest Ecology (3) The forest ecosystem, variations in space and time, classification, ordination techniques, dynamic aspects such as energy flow and nutrient cycling.

512. Forest Genetics (3) Qualitative and quantitative genetic principles and research methods applied in tree breeding.

517. Forest Microclimatology (3) Forest microclimatology quantitative treatment of climate near the ground, with special reference to the role of forests and terrain. Prerequisite: Phys. 202.

519. Forest Hydrology (3) Influence of forest cover on the disposition of precipitation and the application of hydrologic principles and techniques to forest watersheds. Prerequisites: For. 308, C.E. 51.

521. Advanced Silviculture (3) Specific silvicultural practices for the establishment and manipulation of forest stands with respect to recent developments and research needs. Prerequisite: For. 421.

525. Forest Land Use (3) Concepts of supply and demand for forest lands and their allocation to alternative uses. Prerequisites: For. 466 or Ag.Ec. 421; or Geog. 405 and 3 credits in economics.

550. Design and Analysis of Experiments (3) Specialized techniques involved in the design and analysis of complex forestry research problems. Prerequisite: For. 450.

560. Timber Management (3) Technical methods in the organization and control of the forest property for timber production.

575. Applications of Forest Economics and Finance (3) Survey of situations in forestry where business problems and particular circumstances of production, value, and costs are currently significant. Prerequisite: For. 440.

590. Colloquium (1-3)

596. Individual Studies (1-6)

597. Special Topics (1-6)

WILDLIFE MANAGEMENT (W L M) — See page 281.

WOOD SCIENCE (W S)

411. Physical Properties of Wood (3)
412. Mechanical Properties of Wood (3)
413. Chemical Properties of Wood (3)
414. Pulp and Fiber Technology (3)
420. Processing and Machining of Wood (2)
421. Adhesives and Finishes for Wood Products (2)
422. Drying and Preservation (2)
430. Forest Products Manufacturing Systems and Standards (3)
469. Problems in Wood Science (1-6)
491. Logging and Lumbering (3)
495. Forest Products Production Management (3)

502. Wood Fibers (3) Identification and measurement of physical and chemical characteristics of wood fibers used in paper or dissolving pulps.

511. Physical Properties of Wood and Fibers (2) Theories of accessibility, sorption, dimensional stabilization, diffusion, and permeability of cellulosic fibers and solid wood. Prerequisite: W.S. 411.

513. Wood Chemistry (3) Treatment of the chemical components of wood, their distribution and reactions. Prerequisite: W.S. 413.

530. Forest Products Industrial Operations Analysis (2) Research methods with emphasis on programming, simulation, and waiting line problems. Prerequisite: W.S. 495.

531. Mechanical Behavior of Wood (3) Time-dependent properties, theory of failure, rheologic properties, and theory of the mechanical behavior of wood and structural composites.

532. Theory of Adhesion (3) Theory of adhesion as it pertains to bonding of wood, paper-based laminates, fibers, and bonding of wood to dissimilar materials.

590. Colloquium (1-3)

596. Individual Studies (1-6)

597. Special Topics (1-6)

FRENCH (FR)

RICHARD L. FRAUTSCHI, *Head of the Department*
S-404 Burrowes Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Belasco, Brault, Chapman, Frautschi, and LeSage.

Graduate Faculty: Associate Members Anderson, Armitage, Knight, Norton, Tinelli, and Ward.

A student may follow a graduate program in French literature, descriptive and historical linguistics, francophone culture, and language acquisition with a minor in a related field. M.A. candidates may submit either a thesis or a term paper. If the latter is chosen, 6 additional credits in 500-level courses in the major program must be scheduled. The communication and foreign language requirement for the Ph.D. degree may be satisfied by at least an intermediate knowledge of two foreign languages other than French. For the D.Ed. and M.A. degrees an intermediate knowledge of one foreign language other than French is required.

The minimum requirement for admission to an advanced degree program will normally be 36 credits of post-intermediate work in language and literature. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. A brief tape recording must be presented before admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

FRENCH (FR)

417. French Phonology (3) *Mr. Tinelli*
418. French Morphology and Syntax (3) *Mr. Tinelli*
422. Old French Literature (3) *Mr. Knight*
426. French Literature of the Renaissance (3) *Mr. Norton*
430. Contemporary France (3) *Mr. LeBlanc*
435-436. Seventeenth-Century French Literature (3 each) *Mr. Chapman*
445. The French Novel of the Eighteenth Century (3) *Mr. Anderson*
446. French Drama of the Eighteenth Century (3) *Mr. Anderson*
451-452. Nineteenth-Century French Literature (3 each)
460. French Prose of the Twentieth Century (3) *Mr. LeSage*
461. French Poetry and Drama of the Twentieth Century (3) *Mr. LeSage*
470. Advanced Composition and Conversation (3) *Mrs. LeBlanc*
471. Advanced Stylistics (3) *Mrs. LeBlanc*
480. The Teaching of French (4) *Mr. LeBlanc*
491. Problems in French Literature (3-6) *Staff*
499. Foreign Study in French (3) *Staff*

*1G. Elementary French for Graduate Students (3) Designed for students preparing to satisfy language requirements for advanced degrees.

*2G. Elementary French for Graduate Students (3) Continuation of Fr. 1G with reading practice.

500. An Introduction to Old French (3) Analysis of the phonology, morphology, and syntax of the Old French language based on early literary monuments. *Mr. Brault*

503. French Phonology (3) Articulatory and acoustic correlates of distinctive features; synchronic dialectology; phonology in generative grammar. *Mr. Belasco*

504. French Morphology and Syntax (3) Principles of segmentation and decomposition; tagmemics and transformation theory; morphophonemics. *Mr. Belasco*

505. Semantic Theory of the French Language (3) The goals of semantic description; systematic interrelation of semantic generalizations; empirical and methodological constraints. *Mr. Belasco*

516. The Song of Roland (3) Seminar in the Old French *Chanson de Roland,* with emphasis on the problems of textual criticism and literary analysis. *Mr. Brault*

517. Villon (3) The poetry of Villon with reference to the cultural and social context of the late medieval period. *Mr. Knight*

518. Medieval French Drama (3) The development of French drama from its liturgical origins to the flourishing comic theater of the late Middle Ages. *Mr. Knight*

526. Rabelais (3) Seminar in works of François Rabelais, notably Book I *(Pantagruel)* and Book II *(Gargantua),* with emphasis on comic devices and narrative technique. *Mr. Norton*

527. French Renaissance Poetry (3-6) Evaluation of French poetry from Marot through the Pléiade; emphasis on Ronsard and DuBellay. *Mr. Norton*

528. Montaigne (3) Genesis and evolution of Montaigne's creation of the personal essay; influence of the *Essais* in seventeenth- and eighteenth-century French literature. *Mr. Norton*

533. Seventeenth-Century Prose and Poetry (3) The development of Classicism; its apogee and decline as seen in the works of major prose writers and poets. *Mr. Chapman*

534. Moliere (3) The literary achievement of Molière, the comic playwright, director, actor, and founder of the Comédie Française. *Mr. Chapman*

535. Seventeenth-Century French Tragedy (3) The development and triumph of tragedy as a literary genre with special emphasis on the achievement of Corneille and Racine. *Mr. Chapman*

536. La Fontaine (3) The literary artistry of La Fontaine with special emphasis on his contribution as a fabulist. *Mr. Chapman*

540. Voltaire (3) The artistic and philosophical evolution of Voltaire as seen in the tragedy, the philosophical tale, and poetry. *Mr. Anderson*

541. Rousseau (3) Rousseau's rationalistic critique of civilization; his sentimental rehabilitation of the individual, family, state; Rousseau precursor of Romanticism. *Mr. Anderson*

542. Diderot and the Encyclopedists (3) The literary *philosophe* in the Age of Enlightenment with special emphasis on Diderot and his collaborators on the *Encyclopédie. Mr. Frautschi*

561. French Romanticism (3) The Romantic movement in French literature with emphasis upon its major exponents in prose and poetry.

563. French Realism (3) The Realistic movement in French literature with emphasis upon its major exponents in prose and poetry.

565. The Nineteenth-Century French Novel (3) The development of the novel in the nineteenth century with emphasis on Constant, Balzac, Stendhal, Flaubert, and Zola.

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*No graduate credit is given for this course.

567. Twentieth-Century French Theatre (3) Evolution of the French theatre from the plays of the *belle époque* to the avant-garde works of today. *Mr. LeSage*

568. Baudelaire (3) A study of his poetry and his criticism.

569. Masters of Twentieth-Century French Literature (3-6) Major literary figures of contemporary French literature. *Mr. LeSage*

571. French Literary Criticism from Sainte-Beuve to Present (3) Evolution of French literary criticism from Sainte-Beuve, the "father" of modern literary criticism, to contemporary critics. *Mr. LeSage*

580. Seminar in French Literature (3-12) Lectures on methods of research. Students will pursue common and individual investigations in fields selected after consultation with the instructor. *Staff*

581. Theory and Techniques of Teaching French (1-3) *Staff*

586. Symbolism (3) The anti-positivistic tradition in nineteenth-century French literature dealing with the Symbolist School; its antecedents and its subsequent ramifications. *Mr. LeSage*

587. Research Techniques and Bibliography in French Language and Literature (1-3) *Staff*

595. Analysis of French Civilization (3-6) French cultural aspects, other than language and literature, conducted in French with the collaboration of specialists outside the French department. *Mrs. Armitage*

597. Special Topics (1-6)

FUEL SCIENCE (F SC)

Howard B. Palmer, *In Charge of Graduate Programs in Fuel Science*
320 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Austin, Essenhigh, Given, Palmer, Vastola, and Walker.

Graduate Faculty: Associate Member Becker.

This program is one of the options in which a graduate student in the Department of Material Sciences can receive an advanced degree.

Well-instrumented research facilities are available for investigation of the chemical and physical characteristics of coals, fundamentals of coal gasification and liquefaction, flame dynamics in practical combustion systems, industrial fuel efficiency, chemistry and physics of basic combustion phenomena, chemical kinetics of fast gaseous reactions, formation and removal of polluting species in combustion processes, physics and chemistry of carbonaceous solids, organic geochemistry of plant-derived sediments, modeling of energy systems, electrochemical energy conversion, and solar power generation. Students can plan a wide variety of programs of study to suit individual needs; coherent interdisciplinary programs are encouraged. The nonthesis option is available for the M.S. degree.

A basic minimum of 30 course credits is required for the Ph.D. degree, of which at least 12 must be in departmental courses. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Applications will be accepted from persons having degrees in the basic or applied physical sciences or in engineering. Students with a 2.50 junior-senior average will normally be considered for admission. Exceptions may be made for students with special abilities, interests, or backgrounds, such as extensive industrial experience in fuels or combustion.

FUEL SCIENCE (F SC)

400. Fuel Science Research and Design (1-10 per term)
421. Flames (3) *Mr. Palmer*
422. Combustion Engineering (3) *Mr. Essenhigh*
424. Energy and Fuels in Technological Perspective (3) *Mr. Vastola*
430. Air Pollutants from Combustion Sources (3) *Mr. Essenhigh*
431. The Chemistry of Fuels (3) *Mr. Given*

504. Organic Geochemistry of Coal (3) Interdisciplinary study of accumulation of organic sediments and their metamorphism into coal macerals; effects of environment; structure of coal macerals. *Mr. Given*

506. Carbon Reactions (3) Current approaches to heterogeneous reactions in combustion and gasification of carbons and graphite. Prerequisite: Chem. 452. *Mr. Walker*

512. High-Temperature Kinetics and Flame Propagation (3) Laminar and turbulent premixed and diffusion flames; gaseous detonations; rate processes in high-temperature gases. Prerequisite: F.Sc. 421. *Mr. Palmer*

522. Flame Dynamics in Combustors (3) Mixing and reaction in combustion chambers; combustor analysis; residence time distributions; perfectly- and well-stirred combustors; models and experiments. *Mr. Essenhigh*

590. Colloquium (1-3)

596. Individual Studies (1-6)

597. Special Topics (1-6)

Note: *Courses in the use of X-ray diffraction, electron microscopy, spectroscopy, and electronic instrumentation in fuel science studies are listed under Materials Science.*

GENERAL ENGINEERING (GEN E)

Otis E. Lancaster, *Chairman of the Committee on General Engineering*
101 Hammond Building

Degrees Conferred: M.Ed., M.Eng.

This program is designed primarily to give academic preparation to those individuals who will teach engineering subjects in technical institutes and two-year colleges.

For either degree a minimum of 30 credits is required in addition to a scholarly written report. Twenty-four of these credits should be in engineering, physics, and mathematics. A candidate is expected to earn at least 3 credits each in mathematics, physics, and two fields of engineering, or demonstrate competence in them.

For the M.Ed. degree 6 credits must be in education, consisting of one 3-credit course in the theory of learning and teaching and one 3-credit course in internship in college teaching. Fifteen credits must be earned at the 500 level.

For the M.Eng. degree 6 credits may be taken in any field approved by the committee, but at least 12 credits in engineering subjects must be at the 500 level.

For admission an undergraduate degree in engineering, physical science, mathematics, or the equivalent is required. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

GENETICS (GENET)

PAUL W. TODD, *Chairman of the Committee for Genetics*
618 Life Sciences Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Barnes, Buss, Cleveland, Dalton, Davidson, Deering, Fritz, Gerhold, Ginoza, Goodwin, Grun, Hepler, C. W. Hill, R. R. Hill, Hunt, Jones, Keith, MacCluer, Marshall, R. Nelson, O'Mara, Person, Rake, Rapp, Rosenberg, Snipes, Starling, Therrien, Todd, Vesell, Walker, Wilson, Wright, and Zimmerman.

Graduate Faculty: Associate Members Ayers, Brenchley, Craig, Docherty, Dyke, Eckhardt, Funk, Hargrove, R. N. Hill, Johnson, Lausch, Pfeifer, Risius, Shenk, and Thoele.

The program for genetics is an intercollege one, and faculty from the Colleges of Agriculture, Liberal Arts, Medicine, and Science serve as major advisers and on committees for the majors. The student is encouraged to select his major adviser.

Opportunities for graduate study and research are available in biochemical, developmental, microbiological, viral, molecular, and population genetics; cytogenetics; and pharmacogenetics. Organisms available for research include fungi; bacteria; viruses; fish; amphibia; rodents; birds; man; grain, forage, and horticultural plants; and forest trees. The graduate faculty committees for majors have the responsibility and jurisdiction for determining course work, specific requirements in communication skills exceeding the minimum, and research acceptable for satisfying degree requirements. The requirement in communication and foreign language skills for the Ph.D. degree may be satisfied by fulfilling the requirement of the thesis adviser's department or program.

Students with a grade-point average of 3.00 or better and with appropriate course backgrounds in biology, science, and communications courses will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Students with limited deficiencies may be admitted, but they must make up such deficiencies concurrently with their graduate studies.

The following genetics courses are available: Agro. 411, 509, 510; An.Sc. 422, 455; Bioch. 513; Biol. 422, 426, 427, 428, 465; B.Chem. 503; Bphys. 430, 577, 582; C.Med. 503; For. 512; Hort. 407, 444, 507; Micrb. 516, 553, 556; Pharm. 515, 540; P.Path. 543. Twelve credits in these courses and 1 credit in genetics seminar are required for the M.S. degree in genetics or a minor in genetics for a Ph.D.; 15 credits in these courses and 3 credits in genetics seminar are required for a Ph.D. major in genetics. Certain transfer credits for courses in genetics may be accepted as substitutes for the above listed courses.

GEOCHEMISTRY (GCHEM)

ARTHUR L. BOETTCHER, *In Charge of Graduate Programs in Geochemistry*
211 Deike Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Barnes, Bates, Boettcher, Burnham, Dachille, Deines, Griffiths, Keith, Langmuir, Muan, Newnham, Rose, Roy, Smith, Thornton, White, and Wickman.

Graduate Faculty: Associate Members Kerrick, Ohmoto, and Suhr.

Areas of specialization include crystal chemistry, phase equilibria, element distribution and affiliations, isotope geochemistry, geochemical exploration, cosmochemistry, high-temperature and high-pressure geochemistry, and solid state technology.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages or by comprehensive knowledge of one. The nonthesis option is available for the M.S. degree.

Before starting graduate study, an applicant is generally expected to have had a standard introductory course in each of the following four subjects — chemistry, physics, geology, and mineralogy; 12 credits of intermediate-level work in any one or a combination of chemistry, physics, and geological science; and mathematics through integral calculus. Students who have taken somewhat less than the indicated minimum of subjects may be admitted but must make up their deficiencies concurrently with their graduate studies.

Students who present a 3.00 grade-point average in their basic science and geoscience subjects and other appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

GEOCHEMISTRY (GCHEM)

402. Introduction to Organic Geochemistry (3) *Mr. Given*
457. Geochemical Exploration (3) *Mr. Rose*

502. (Geol. 502) Carbonates in the Marine Environment (3) Ancient carbonate rocks and recent carbonate sediments, with emphasis on modern field and laboratory methods and a multidisciplinary approach. *Mr. Weber*

512. (Mat.Sc. 512) Principles of Crystal Chemistry (2-4) Relation of structure to ionic size and nature; influence of pressure and temperature on structure; chemical-structural defects, crystalline solutions, phase-transitions. *Mr. Roy*

513. Phase Equilibria in Mineral Systems at High Temperatures (2-4) Interpretation of phase diagrams with emphasis on high-temperature oxide systems at atmospheric pressure; measurement of p-t-x, determination of equilibrium diagrams. *Mr. Muan*

514. Element Distribution in the Earth (3) Principles and data from studies of phase equilibria, petrology, and crystal structure as related to distribution of elements in minerals, rocks, and the earth. *Mr. Wickman*

517. Age Determinations (1-2) Geochemistry of radioactive elements and their daughters; age determination techniques and observations. *Mr. Deines*

518. Stable Isotope Geochemistry (3) Theory of isotope fractionation mechanisms; its application to a wide range of problems in the earth and planetary sciences. *Mr. Deines*

520. P-T-X Phase Equilibria (3) Phase equilibrium in mineral systems with pressure as a variable. *Mr. Boettcher*

522. Geochemistry of Aqueous Systems (2-3) Ionic and molecular equilibria related to stabilities and solubilities of minerals: Eh-pH, PO_2-pH relations applied to ground water, sea water, hydrothermal fluids. Prerequisites: Chem. 451-452, Min. 483, 484. *Messrs. Barnes and Schmalz*

523. Water-Resource Geochemistry (2-4) Topics and problems concerning the chemical quality of surface waters and ground waters related to hydrogeologic and cultural controls. *Mr. Langmuir*

524. (Mat.Sc. 524) Vibrational Spectra of Materials and Minerals (2) Infrared and Raman spectroscopy of solid materials with applications to crystal chemistry, materials characterization and glass research. Prerequisites: Phys. 412, 471. *Mr. White*

525. Electronic Properties of Minerals (2) Application of spectroscopy to mineralogy, Crystal field, EPR, NMR, Mossbauer spectra. Application to order-disorder, element distribution, mineral stability. Prerequisites: Phys. 412, 471. *Mr. White*

590. Colloquium (1-3)

596. Individual Studies (1-6)

597. Special Topics (1-6)

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in geochemical studies are listed under Mineralogy.*

GEOGRAPHY (GEOG)

Wilbur Zelinsky, *Head of the Department*
403A Deike Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Gould, Lewis, Miller, Rodgers, Simkins, Wernstedt, Williams, and Zelinsky.

Graduate Faculty: Associate Members Abler, Downs, and Knight.

The student may concentrate in subjects that call upon the special skills and interests of the staff. At the present time these include: geographic theory; methods of geographic analysis; the cultural geography of Anglo-America; population problems and the human use of the environment; microspatial behavior of individual actors in space; macrospatial analysis in regional and urban development; and regional development problems in Africa, Latin America, Southeast Asia, and southern Europe. All students receive training in cartographic, statistical, and bibliographic techniques.

Students wishing to specialize in the field of population may also qualify for admission to the Population Issues Studies Program. This program is a course of study focusing on the social, economic, and geographical policy-related issues resulting from the dynamics of population trends, especially in developed nations. In addition to departmental admission requirements, the Population Issues Studies Program committee evaluates the student's interest and aptitude for the training program, which consists of a minimum of 21 credits of interdisciplinary course work in population.

For the M.S. degree, the student has the option of completing a thesis or two papers. The master's program is broadly based, designed to provide a beginning graduate student with basic training in systematic fields as well as in geographic theory and research techniques. This basic training underlies more specialized study at the doctoral level where a candidate selects two fields of concentration. A student may elect to specialize in the geography of a region only if faculty members have research experience in that region. The communication and foreign language requirement for the Ph.D. degree may be satisfied by either a reading competence in a modern foreign language with faculty approval or comparable facility in mathematics, statistics, or computer science.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 230).

GEOGRAPHY (GEOG)

401. Historical Geography of North America (3) *Mr. Lewis or Mr. Zelinsky*
402. Cultural and Anthro-Geography (3) *Mr. Zelinsky*
405. Geography of Population (3) *Mr. Zelinsky or Mr. Simkins*
406. Human Use of Environment (3) *Mr. Knight*
407. Geography of Settlement (3) *Mr. Williams*
410. Cartography — Map Design and Construction (3) *Mr. Sibert*
412. The Geography of the Future (3) *Mr. Abler*

413. Behavioral Approaches to Geography (3) *Mr. Downs*
420. Urban Geography (3) *Mr. Caruso*
427. Geography of the Soviet Union (3) *Mr. Rodgers*
430. Agricultural Geography (3) *Mr. Knight*
433. Regional Climatology (3) *Mr. Wernstedt*
434. Regional Physiography (3) *Mr. Lewis*
440. Geography of Middle America (3) *Mr. Simkins*
441. Geography of South America (3) *Mr. Simkins*
442. Regional Systems in Europe (3) *Mr. Miller*
443. Geography of the Orient (3) *Mr. Wernstedt*
444. Geography of Africa (3) *Mr. Knight*
445. Geography of Southern Asia (3) *Mr. Wernstedt*
450. Development of Geographic Thought (3) *Mr. Abler*
451. Map Interpretation (3) *Mr. Lewis*
452. Interpretation of Aerial Photographs (3) *Staff*
454. Spatial Analysis I (3) *Mr. Gould or Mr. Williams*
455. Spatial Analysis II (3) *Mr. Gould or Mr. Williams*
457. Geographic Data Systems (4) *Mr. Williams or Mr. Sibert*
460. Political Geography (3) *Mr. Lewis or Mr. Williams*
470. Industrial Location and Development (3) *Mr. Rodgers*
475. Geography of Communications Systems (3) *Mr. Abler*
480. Manufactural Systems Analysis (3) *Mr. Miller*
489. Problems in Geography (3) *Staff*
497. Directed Readings (1-9) *Staff*

500. Introduction to Geographic Research (3)

501. Geographic Bibliography (1) An introduction to the techniques of bibliographic search and the writing of research papers in geography. Prerequisite: Geog. 500.

502. Regional Theory (3) Taxonomic methods of uniform — functional regionalization; canonical linkages; intraregional relationships; Wilson models of macrocanonical ensembles.

503. Advanced Regional Geography (3-12) Intensive study at an advanced level of selected regions or sections of the continents. Prerequisite: 12 credits in geography.

504. Physical Geography Seminar (3-12) The examination of current problems and theories in physical geography through critical discussion of the literature and student research.

505. Economic Geography Seminar (3-12) The examination of current problems and theories in economic geography through critical discussion of the literature and original student research.

506. Political Geography Seminar (3-6) The exploration of current problems and theory in political geography through critical discussion of the literature and original student research. Prerequisite: Geog. 460.

508. Cultural Geography Seminar (3-6) The exploration of current problems and theory in cultural geography through critical discussion of the literature and original student research.

509. Population Geography Seminar (3) Selected problems in population geography with emphasis on analysis and presentation of data. Prerequisite: Geog. 405.

517. Geographic Modeling (1) Spatial modeling, mapping and transformations of elementary geographic problems.

520. Metropolitan Analysis (3) Land use models, urban factorial ecology; intraurban movements; urban renewal, ghetto structure, residential change; commercial structure, blight. Prerequisite: Geog. 420 or 456.

567. Applied Quantitative Methods (3) Simulation, topological, queuing, programming, factor analytic, discriminant, and game theoretic models applied to geographic problems of spatial diffusion and interaction. Prerequisite: Geog. 456.

590. Colloquium (1-3)
596. Individual Studies (1-6)
597. Special Topics (1-6)

GEOLOGY (GEOL)

ROBERT F. SCHMALZ, *In Charge of Graduate Programs in Geology*
303 Deike Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Cuffey, Gold, Guber, Parizek, Ridge, Schmalz, Scholten, Spackman, Traverse, Voight, Weber, Williams, and Wright.

Programs are offered in stratigraphy, paleontology, sedimentation, paleobotany, palynology, regional and structural geology, geomorphology, ground water geology, engineering geology, marine geology and chemical oceanography, coal geology, coal petrology, and geology of metallic and nonmetallic deposits.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages or by comprehensive knowledge of one. The student has the option of a thesis or a paper for the M.S. degree.

For admission 25 credits in chemistry, physics, mathematics, and biological sciences and at least 18 in geology and mineralogy are required. Students who have taken somewhat less than the indicated minimum in these subjects may be admitted but must make up their deficiencies concurrently with their graduate studies.

Students may be accepted with a previous degree in geophysics, physics, mathematics, engineering, earth sciences, or a closely allied field. Students whose grade-point average in courses pertinent to geology is below 3.00 will be considered for admission when there are strong indications that a 3.00 average can be maintained at the graduate level. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the 3.00 minimum grade-point average may be made for students with special backgrounds, abilities, and interests.

GEOLOGY (GEOL)

400. Surface Geological Processes for Teachers (3) *Mr. Weber*
401. Earth History for Teachers (3) *Mr. Cuffey*
402. Field Methods for Teachers (3) *Mr. Guber*
405. Evolution of Coastlines (3) *Mr. Weber*
410. Structural Geology (3) *Mr. Gold*
420. (Biol. 420) Paleobotany (3) *Mr. Spackman*
421. Introduction to Coal Petrology (3) *Mr. Spackman*
422. Coal Measure Geology (3) *Mr. Davis*
423. (Biol. 423) Introductory Palynology (3) *Mr. Traverse*
427. (Biol. 427) Evolution (3) *Mr. Cuffey*
430. Paleontology (3) *Mr. Guber*
435. Paleoecology (3) *Mr. Cuffey*
440. Marine Geology (3) *Mr. Schmalz*
445. Coastal Geology (4) *Messrs. Guber, Schmalz, and Williams*
451. Economic Geology (3)
452. Introduction to Hydrogeology (3) *Messrs. Langmuir and Parizek*
453. Mechanics of Geological Materials (3) *Mr. Voight*
461. Geology of North America (3) *Mr. Wright*
462. Principles of Geomorphology (3-6)
470. Introduction to Field Geology (3) *Mr. Wright*

472. Field Geology (5) *Mr. Gold*
481. Geology of Oil and Gas (3) *Mr. Scholten*
490. Stratigraphy (3) *Mr. Williams*

502. (Gchem. 502) Carbonates in the Marine Environment (3) Ancient carbonate rocks and recent carbonate sediments, with emphasis on modern field and laboratory methods and a multidisciplinary approach. *Mr. Weber*

*503. Paleontology (3-9) Morphology of animal groups significant for their fossils; nature of species and faunal zones. Seminars may be arranged for studies of special fossil groups, microfossils, paleoecology. *Mr. Cuffey*

504. History and Foundations of Geology (2-4) Theoretical aspects of geology: spatio-temporal organization of matter, dynamic processes, sequential development; basic patterns and history of scientific thought. *Mr. Williams*

**506. Sediments of the World (2-6) Evolution of sediments from Archean to recent; relationship of sedimentation to geotectonism; kratonic and geosynclinal sediments; cyclicity. Prerequisites: Min. 512, 514. *Messrs. Scholten and Williams*

507. Seminar in Geomorphology (3-6) Classic and current literature in geomorphology.

509. (Mn.Ec. 509) Geology and Economics of the Construction Materials (3) Occurrence, origin, and marketing of the mineral materials used by the construction industry. Economic and geologic evaluation of actual deposits.

510. (Mn.Ec. 510) Geology and Economics of the Industrial Minerals (3) Occurrence, origin, and marketing of the industrial minerals and evaluation of deposits. Chemical and ceramic raw materials emphasized.

511. Ore Deposits: Principles (3-6) Geological and geochemical processes controlling ore deposition; genetic classification of ore deposits. Prerequisite: Geol. 451.

512. Ore Deposits: Types (1-6) Geologic history and field examination of selected ore bodies; forming media; causes, sequences, and loci of emplacement; wall rock alteration; secondary enrichment. Prerequisite: Geol. 511.

524. Coal Petrology (1-6) Microscopy, source materials, coalification, constitution, classification of peats, lignites, bituminous coal, anthracite. *Mr. Spackman*

526. Problems in Palynology (1-6) Systematics: paleoecological palynology; Paleozoic palynology; Mesozoic and Cenozoic palynology; Pleistocene vegetational history. *Mr. Traverse*

540. Chemical Oceanography (3) Chemical reactions in sea water and at the sea floor related to sedimentation and diagenesis. *Mr. Schmalz*

545. Glacial Geology (3) Glaciers: their characteristics, causes, deposits, landforms, effects in periglacial regions. *Mr. Parizek*

546. Principles of Photogeology (3) Use of aerial photographs and mosaics in structural, geomorphic, and rock distribution studies and in compilation of maps. Prerequisites: Geol. 410, 462.

551. Dynamic Structural Geology and Geotectonics (3-6) Phenomena of fracturing, faulting, folding; stress and (finite) strain analysis, physical and analytical models; deformational environments; tectogenesis and orogenesis. *Messrs. Scholten and Voight*

555. Advanced Structure and Petrofabrics (1-3) Macroscopic and mesoscopic recognition, measurement, and interpretation of small-scale rock structures and mineral orientation patterns in deformed rocks. *Mr. Gold*

571. Geology Field Trip (1 per year) Field study of regional geologic features with trips in successive years to differing geologic provinces.

581. Habitat of Oil (3) Geologic setting of petroleum as determined by basin tectonism, sedimentation, hydraulic and capillary forces, and reservoir textures. *Mr. Scholten*

*Credits to be arranged, 3-6 per term.
**Credits to be arranged, 2-3 per term.

590. Colloquium (1-3)

596. Individual Studies (1-6)

597. Special Topics (1-6)

Note: *Additional general courses in this field are listed under Geological Sciences. Courses in related fields are listed under Geochemistry, Geophysics, and Mineralogy-Petrology.*

GEOPHYSICS (GPHYS)

Shelton S. Alexander, *In Charge of Graduate Programs in Geophysics*
204 Mineral Sciences Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Alexander, Bell, and Howell.

Graduate Faculty: Associate Members Graham, Greenfield, Lavin, and Sammis.

Students may specialize in seismology, physical properties of rocks, geophysical surveying, geomagnetism, paleomagnetism, geoelectricity, gravity, wave propagation, time-series analysis, space applications of geophysics, tectonics, earth physics, and planetary sciences.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages or by comprehensive knowledge of one. The nonthesis option is available for the M.S. degree.

For admission an applicant is generally expected to have had mathematics through differential equations; a standard introductory course each in physics, chemistry, and earth sciences; and at least 16 credits of intermediate-level work in any one or a combination of these subjects. Applicants who have taken somewhat less than the indicated minimum in these subjects may be admitted but must make up their deficiencies concurrently with their graduate studies.

Students may be accepted with a previous degree in geophysics, physics, mathematics, engineering, earth sciences, or a closely allied field. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Students with special backgrounds, abilities, and interests whose grade-point average in courses pertinent to geophysics is below 3.00 will be considered for admission when there are strong indications that a 3.00 average can be maintained at the graduate level.

GEOPHYSICS (GPHYS)

400. Physics of the Earth for Teachers (3)
406. Physics of the Earth (3) *Mr. Graham*
407. Well Logging (3) *Mr. Lavin*
408. Geophysical Surveying (3) *Mr. Lavin*
415. Gravity and Magnetic Surveying (3) *Mr. Lavin*
416. Electrical Surveying (3) *Mr. Greenfield*
417. Analysis of Time Series (3) *Mr. Lavin*
418. Potential Theory Applied to Earth Problems (3) *Mr. Alexander*

502. Seismic Instruments (3) Characteristics and design of seismometers and seismic recorders.

504. Communication Theory for Geophysicists (3) Basic theory of random processes leading to and including optimum filters; geophysical applications to gravity and seismic data analysis.

507. Seismology (3 per unit)
Unit A. Basic theory; seismic methods for inferring structure of planetary interiors; observational techniques; seismic event location, magnitude, and damage potential.
Unit B. Advanced wave propagation theory; mathematical representation of seismic sources; inversion theory; computational methods.

508. Tectonics (3) Seminar in the cause and nature of the principal deformations of the earth.

516. Introduction to Nuclear Processes in Geologic Settings (2) Natural radioactivity and its measurement, interpretation, and use in research and exploration.

521. Thermal State of the Earth (2) Methods and instrumentation of geothermal measurements; geothermal observations; development of the theory of the thermal state of the earth.

590. Colloquium (1-3)

596. Individual Studies (1-6)

597. Special Topics (1-6)

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in geophysical studies are listed under Mineralogy.*

GERMAN (GER)

Stanley R. Townsend, *Head of the Department*
S-323 Burrowes Building

Degrees Conferred: Ph.D., M.A., M.Ed.

Graduate Faculty: Senior Members Ebbinghaus, Kopp, Preisner, and Townsend.

Graduate Faculty: Associate Members Browning, de Levie, Keune, and Ziegler.

There is opportunity for major emphasis upon literature, philology, or the teaching of German. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages.

Minimum qualifications for admission include 27 undergraduate credits in German beyond the intermediate level; provision is made, however, for admission with limited deficiencies. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Students may qualify for the M.A. and M.Ed. degrees either by writing a thesis — which is recommended if a student wishes to be considered for Ph.D. candidacy — or by submitting an essay to the department and taking additional 500-level German courses in lieu of 6 credits of thesis research.

GERMAN (GER)

401. Advanced Composition (3)
411. The Teaching of German (3)
412. Structural Analysis of Modern German (3)
430. History of the German Language (3)
440. German Studies (3)
443. (C.Lit. 443) Literary Relations of Germany with England and America (3-9)
445. The Vikings (3)
450. Medieval German Literature I (3)
451. Medieval German Literature II (3)

452. Literature of the Renaissance (3)
460. Literature of the Baroque (3)
461. Literature of the Enlightenment (3)
462. Literature of the Late Eighteenth Century (3)
470. Goethe (3)
471. Schiller (3)
472. Romanticism (3)
480. Realism (3)
481. Early Twentieth Century (3)
482. Recent German Literature (3)
495. Independent Study (1-9)

*1G. Elementary German for Graduate Students (3) Designed for students preparing to satisfy language requirements for advanced degrees.

*2G. Elementary German for Graduate Students (3) Continuation of Ger. 1G with opportunity for reading in special fields.

500. Bibliography and Research Techniques (3) Introduction to tools and methods of research, designed for students preparing for independent investigation of problems in German literature and language.

520. Introduction to Middle High German (3) Descriptive and historical grammar; readings in simple Middle High German texts.

521. Readings in Middle High German (3) Intensive reading in Middle High German literature, especially of the *Blütezeit.* Prerequisite: Ger. 520.

522. Old High German (3) Essentials of the grammar with special treatment of the High German sound shift and of ablaut and umlaut; reading of works written before 1100 A.D.

523. Gothic (3) Introduction to the historical and comparative Germanic grammar; emphasis on the Gothic language and texts. Suitable for advanced students in English.

525. Old Icelandic (3) Introduction to Old Icelandic grammar; readings in Old Icelandic prose. Suitable for advanced students in English.

531. Seminar in Medieval German Languages and Literatures (3-6)

541. Seminar in the Literature of the Reformation and Baroque (3-6)

551. Seminar in the Literature of the Enlightenment and the Age of Goethe and Schiller (3-6)

561. Seminar in Post-Idealistic Literature (3-6)

571. Seminar in Modern German Literature (3-6)

581. Seminar in Literary Genres (3-12) Special studies in the German lyric, drama, short story, and novel.

591. Seminar in German Literary Criticism (3)

595. Independent Study (1-9) Selected projects in the study of German literature and philology. Prerequisite: Ger. 500.

*No graduate credit is given for this course.

HIGHER EDUCATION (HI ED)

LARRY L. LESLIE, *In Charge of Graduate Programs in Higher Education*
319 Rackley Building

Degrees Conferred: D.Ed., M.Ed.

Graduate Faculty: Senior Members Anderson, Blocker, Gillie, Ikenberry, Leslie, Martorana, and Sweitzer.

Graduate Faculty: Associate Members Flexner, Godbey, Guisti, Lindsay, Mortimer, and Richardson.

The graduate program in the higher education major has as its goal the preparation of individuals who will pursue careers as administrators, faculty, or researchers in the nation's colleges and universities and in a variety of public and private agencies and associations. With emphasis on the systematic study of higher education, the program builds on the scholarly and scientific disciplines offered throughout the University and applies these studies to the professional functions and responsibilities which its graduates will assume.

With mounting awareness of the need for educational reforms and for improved teaching, other departments throughout the University encourage their graduate students to pursue a minor in higher education. The higher education faculty cooperates in this program — which is administered through the students' major departments — by offering a number of courses and seminars designed to promote understanding of post-secondary-school teaching.

The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Those with a junior-senior average of 3.00 are usually admitted to the M.Ed. program. In addition, students with a graduate average of 3.50 and a standardized test score comparable to a 60 on the Miller Analogies Test (MAT) are usually admitted to the D.Ed. program. Persons with grade averages of 2.70 (for the M.Ed. program) or 3.20 (for the D.Ed. program), with MAT scores of 50, and with special backgrounds, abilities, and interests will be considered for admission. Some outstanding students may be admitted to the doctoral program with only the baccalaureate degree, but they will earn the master's degree *en route.* For information about special requirements in the higher education major, write: Higher Education, The Pennsylvania State University, 319 Rackley Building, University Park, Pa. 16802.

HIGHER EDUCATION (HI ED)

460. (Ed.Adm. 460) INTRODUCTION TO ADULT EDUCATION (3)

545. HIGHER EDUCATION IN THE UNITED STATES (2-3) A basis for all courses in higher education. Current issues are analyzed and trends of the future anticipated.

546. COLLEGE TEACHING (2-3) Principles involved in teaching at the college level; effective use of teaching aids; criteria used in evaluation.

547. INTERNSHIP IN HIGHER EDUCATION (1-9) Supervised experience in administrative offices, in research, on instructional teams, and in college teaching.

548. CURRICULUMS IN HIGHER EDUCATION (2-3) Various types of curriculums and philosophies underlying them; ways in which curriculums are developed; elective versus required courses; evaluation of achievement.

549. COMMUNITY JUNIOR COLLEGE AND THE TECHNICAL INSTITUTE (2-3) Distinctive contributions to meeting the need for post-secondary education; development, functions, curriculum and instruction, government, administration and finance.

550. THE PROFESSIONS AND THE EDUCATION OF TEACHERS (3) The nature of a profession and dimensions of professional education in the United States are explored. Trends and issues examined.

552. Administration in Higher Education (2-3) Philosophy of administration; principles of scientific management and their application in colleges and universities; case studies of administrative problems. Prerequisite: courses or experience in higher education.

554. The History of American Higher Education (3) An examination of the development of American higher education against the background of influential social, political, economic, and intellectual issues.

555. Seminar in Higher Education (1-6) Special topics in higher education.

556. College Students (3) Characteristics of college students; changes during college years; educational challenges and responses. Prerequisites: Hi.Ed. 545 or Psy. 426 or I.F.S. 435.

589. Problems, Projects, and Area Studies in Higher Education (1-6) Independent work in the study of topics in higher education, or development of new curriculums, materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of the department head.

HISTORY (HIST)

Kent Forster, *Head of the Department*
601 Liberal Arts Tower

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty: Senior Members Borza, Brown, Dahmus, Eggert, Forster, Frantz, Hassler, Maddox, McNall, Murray, Silverman, Sun, and Utechin.

Graduate Faculty: Associate Members Ameringer, Duiker, Enteen, Goldschmidt, Green, Knight, Linker, Meier, Spielvogel, and Stebbins.

Graduate work is offered in the following areas of history: ancient, medieval, Europe since 1500, Great Britain and the British Empire, Russia and Eastern Europe, the Middle East, the Far East, the United States, and Latin America. These areas are subdivided into chronological, national, and topical fields.

The candidate for the M.A. or M.Ed. degree selects one of the above areas for his master's examination. He must take some courses in an area in history other than his examination area and in a cognate field. (The cognate field for an M.Ed. candidate must be in education.) With the consent of his adviser, a master's candidate may substitute additional course work and a paper for a thesis.

The candidate for the doctor's degree must pass examinations in one of the above areas, in a thesis field within that same area, and in one field from a second area. He must also pass an examination in a single cognate field, or in a study area made up of a number of academic disciplines related to the subject of his thesis. The communication and foreign language requirement for the Ph.D. may be satisfied by a reading knowledge of two foreign languages or one language and work in quantitative techniques. The D.Ed. candidate has no foreign language requirement; however, he must minor in education.

The entering student should present evidence of undergraduate course work covering the history of Europe from ancient times to the present and the history of America from its discovery to the present. Students with a 3.00 junior-senior average and better than a 3.00 average in all undergraduate history courses and appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Each applicant must provide Graduate Record Examination scores and at least three letters of recommendation.

HISTORY (HIST)

400. Selected Topics in History (3-6)
401. Classical Civilization (3) *Messrs. Borza and Harvey*
403. The Middle Ages from Constantine to the Crusades (3)
404. The Middle Ages from the Crusades to the Renaissance (3)
405. Byzantine Civilization (3)
408. Intellectual History of the Middle Ages (3)
410. The Renaissance (3) *Mr. Spielvogel*
411. The Reformation (3) *Mr. Spielvogel*
413. The Age of Absolutism (3) *Mr. Green*
414. The French Revolution and the Napoleonic Era (3) *Mr. Green*
417. Nineteenth-Century Europe (3) *Mrs. Rosenblatt*
419. Recent European History (3) *Mr. Forster*
422. History of the American Frontier (3) *Mr. McNall*
425. History of American Political Parties (3)
426. The Diplomatic History of the United States to 1900 (3) *Mr. Maddox*
427. The Diplomatic History of the United States Since 1900 (3) *Mr. Maddox*
428. American Military History (3) *Mr. Hassler*
430. Colonial America to 1753 (3) *Mr. Frantz*
431. Revolutionary America, 1753-1783 (3) *Mr. Frantz*
432. The Formative Period of American History (3) *Mr. Brown*
433. The Middle Period of American History (3) *Mr. McNall*
434. The United States in Civil War and Reconstruction (3) *Mr. Hassler*
435. The Emergence of Modern America (3) *Mr. Eggert*
436. America Between the Wars (3) *Mr. Murray*
437. Recent American History (3) *Mr. Murray*
439. History of England in the Middle Ages (3)
440. Britain Under the Tudors and Stuarts, 1485-1688 (3) *Mr. Linker*
441. Great Britain, 1688-1832 (3) *Mr. Linker*
442. History of Russia to 1700 (3) *Mr. Utechin*
443. Imperial Russia, 1700-1917 (3) *Mr. Utechin*
444. Eastern Europe in Modern Times (3) *Mr. Enteen*
446. Intellectual and Cultural History of Europe 1600-1800 (3) *Mrs. Knight*
447. Social and Economic History of Europe Since 1750 (3) *Mr. Silverman*
448. Intellectual and Cultural History of Europe Since 1800 (3) *Mrs. Knight and Mr. Silverman*
449. Diplomatic History of Europe Since 1870 (3) *Mr. Forster*
452. Social and Cultural History of the United States Since 1783 (3) *Mr. Brown*
453. American Economic History in the Agricultural Era (3) *Mr. McNall*
454. American Economic History in the Industrial Era (3) *Mr. Eggert*
456. (L.S. 456) History of American Organized Labor Since 1877 (3) *Mr. Eggert*
458. Constitutional History of the United States to 1877 (3) *Mr. Stebbins*
459. Constitutional History of the United States Since 1877 (3) *Mr. Stebbins*
460. Latin America and the United States (3) *Mr. Ameringer*
462. Mexico and the Caribbean Nations in the Twentieth Century (3) *Mr. Ameringer*
463. Spanish Conquest of the New World (3) *Mr. Garner*
464. Latin-American Independence Movements (3) *Mr. Garner*
466. The Rise of the Greek Polis (3) *Mr. Borza*
467. Alexander the Great and the Hellenistic World (3) *Mr. Borza*
468. The Roman Republic (3) *Mr. Harvey*
469. The Pax Romana (3) *Mr. Harvey*
470. The Later Roman Empire (3) *Mr. Harvey*
471. Nineteenth-Century China (3) *Mrs. Sun*
472. Twentieth-Century China (3) *Mr. Duiker*
479. Twentieth-Century Southeast Asia (3) *Mr. Duiker*

480. History of Arabic Civilization, 600-1258 (3) *Mr. Goldschmidt*
481. The Ottoman Empire and Other Muslim States (3) *Mr. Goldschmidt*
482. The Contemporary Middle East (3) *Mr. Goldschmidt*
485. History of Central and East Africa (3) *Mr. Griffith*
486. History of West Africa (3) *Mr. Griffith*
491. History of the Soviet Union (3) *Mr. Enteen*
492. Great Britain Since 1832 (3) *Mr. Linker*
497. Germany Since 1640 (3) *Mr. Silverman*

501. Historical Method (3) *Mr. Meier*

502. Historiography (3) *Messrs. Borza and Meier*

503. Studies in Medieval English History (3-6) A seminar in the political, economic, and cultural history of England in the Middle Ages.

504. Medieval Civilization (3-9)

505. The Age of the Reformation (3-6) *Mr. Spielvogel*

507. Studies in European History, 1600-1750 (3-6) *Mrs. Knight and Mr. Green*

508. Studies in European History, 1750-1900 (3-6) *Mr. Silverman*

509. Studies in Twentieth-Century Europe (3-6) *Messrs. Forster and Silverman*

512. Studies in Pennsylvania History (3-6) *Mr. Frantz*

520. Colonial and Revolutionary America (3-6) *Mr. Frantz*

533. The United States, 1783-1860 (3-6) *Mr. McNall*

534. The United States, 1860-1877 (3-6) *Mr. Hassler*

535. The United States, 1877-1919 (3-6) *Mr. Eggert*

536. The United States Since 1919 (3-6) *Mr. Murray*

538. Diplomatic History of the United States (3-6) *Mr. Maddox*

539. Economic History of the United States (3-6) *Messrs. McNall and Eggert*

540. Studies in British History (3-6) *Mr. Linker*

544. Seminar in Eastern European History (3-6) *Messrs. Utechin and Enteen*

545. Studies in Russian and Soviet History (3-6) *Messrs. Utechin and Enteen*

552. Cultural History of the United States (3-6) *Mr. Brown*

559. Studies in Constitutional History (3-9) A graduate seminar examining constitutional developments in their historical context through readings, class discussions and research papers. *Mr. Stebbins*

562. Seminar in Latin-American History (3-6) *Mr. Ameringer*

563. Studies in the History of the Caribbean Area (3) Prerequisites: Hist. 22, 23. *Mr. Ameringer*

568. Studies in Greek History (3-6) *Mr. Borza*

569. Studies in Roman History (3-6)

571. Studies in Asian History (3-9) *Mrs. Sun and Mr. Duiker*

581. Studies in Middle Eastern History (3-6) *Mr. Goldschmidt*

597. Special Topics (1-6)

HOME ECONOMICS EDUCATION (HE ED)

MARJORIE EAST, *Head of the Department*
212 Rackley Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members East, Ray, and Shear.

Graduate Faculty: Associate Member Weis.

Research and graduate courses may be chosen to give emphasis to special areas of interest in home economics education, such as curriculum development; evaluation; teaching at the elementary, secondary, adult, or higher education levels; supervision; administration in colleges; or research.

Students who have majored as undergraduates in some aspect of home economics and who have achieved a grade-point average of at least 2.50 in their junior and senior years will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. Students wishing to be admitted to the doctoral programs must have completed a master's degree and will be admitted subject to limitations of departmental facilities. Exceptions will be made for students with special backgrounds, abilities, and interests.

HOME ECONOMICS EDUCATION (HE ED)

400v. SPECIAL PROBLEMS IN HOME ECONOMICS EDUCATION (1-3)
406v. AUDIO-VISUAL METHODS FOR HOME ECONOMICS (1-4)
410v. SUPERVISION OF STUDENT TEACHERS (1-3)
427v. TEACHING HOME ECONOMICS (3)
443v. ADULT EDUCATION IN HOME ECONOMICS (3)
463v. SENIOR SEMINAR (2)
466v. STUDENT TEACHING (9)
477v. CURRICULUM DEVELOPMENT FOR HOME ECONOMICS IN SECONDARY SCHOOLS (3)
478v. APPRAISING STUDENT PROGRESS IN HOME ECONOMICS (3)
479v. READINGS IN HOME ECONOMICS EDUCATION (1-4)
480v. PROBLEMS IN TEACHING HOME ECONOMICS (3-6)
481v. EMPLOYMENT PREPARATION PROGRAMS IN VOCATIONAL HOME ECONOMICS (3)

502, 502v. HOME ECONOMICS INSTRUCTION AT THE COLLEGE LEVEL (3) Teaching techniques suitable for college instruction in home economics; for prospective home economics college teachers.

503, 503v. HOME ECONOMICS TEACHER EDUCATION (3) Organization of college programs of teacher education; use of resources; records; field services; recruitment and selection of personnel. Prerequisite: two years' experience in teaching home economics.

504, 504v. EDUCATIONAL ISSUES AND HOME ECONOMICS (3) Contemporary issues in education and their relationship to the teaching of home economics. Prerequisite: teaching experience.

510, 510v. EDUCATIONAL LEADERSHIP IN HOME ECONOMICS (2-6) Principles of educational leadership for home economics preparing for administration; supervision of city and state programs; supervision of student teachers. Prerequisites: graduation from a four-year teacher education major and two years' teaching experience in home economics.

511, 511v. INTERNSHIP IN HOME ECONOMICS SUPERVISION AND ADMINISTRATION (2-8) Opportunity to understudy an educational leader in student teacher supervision, state supervision, department or college administration, or regional consultation. Prerequisite: H.E.Ed. 510.

518, 518v. Evaluation of Home Economics Programs (3) Methods of evaluating progress toward goals in home economics education and use of findings in program planning and revision.

521, 521v. Home Economics Education Seminar (2-3) Selected topics and recent developments in home economics education. Conferences and guidance relative to individual research problems.

530, 530v. Problems in Home Economics Education (1-6 per term) Individual investigation of problems related to the teaching, supervision, or administration of home economics education.

HORTICULTURE (HORT)

Roger W. Hepler, *Head of the Department*
103 Tyson Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members Bergman, Grun, Hitz, Larson, McArdle, Ritter, Shannon, Smith, Stinson, and Tukey.

Graduate Faculty: Associate Members Beelman, Craig, Haramaki, Hepler, Kuhn, Martsolf, Mastalerz, Pfahl, and White.

Students may specialize in climatology, propagation, several phases of production, fruit and vegetable processing, plant genetics and breeding, plant nutrition, and various environmental and post-harvest physiological studies of horticultural crop species.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by one of three options: (1) comprehensive competence in one language, (2) reading examination or two-course sequence in two languages, or (3) reading examination or two-course sequence in one language plus 6 credits in other communications skills.

Students wishing additional credits in floriculture, olericulture, ornamental horticulture, plant breeding and genetics, plant nutrition, climatology, or pomology should register for Hort. 501.

Prerequisites for admission vary according to the area of specialization; but basic courses in physical sciences, mathematics, biological sciences, communication skills, and social sciences and humanities are required. Students who lack prerequisite courses may be admitted but are required to fulfill deficiencies without degree credit.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students.

HORTICULTURE (HORT)

401. Plant Propagation (3) *Mr. Haramaki*
402. Plant Nutrition (3) *Mr. Bergman*
403. Horticultural Plants and Their Environment (3) *Mr. Mastalerz*
404. Advanced Horticultural Crop Science (3-12)
405. Senior Seminar in Horticulture (1-2)
407. Plant Breeding (3) *Mr. Garwood*
412. Post-Harvest Physiology (3) *Mr. Shannon*
444. Advanced Plant Breeding (3-6) *Mr. Craig*
447. Problems in Horticulture (1-9)
451. Flower Store Management (4) *Mr. Pfahl*

501. Experimental Problems in Horticultural Science (1-12) Investigation of problems in floriculture, olericulture, ornamental horticulture, plant breeding, nutrition, or pomology.

506. Nutrition of Horticultural Crops (2-4) Principles, applications, and interpretations of diagnostic methods for determining fertilizer requirements of horticultural crops. *Mr. Smith*

507. Physiological Genetics and Plant Breeding (3) Physiological genetics in improving the biological efficiency and utilization of plants. Prerequisites: Bioch. 42 or Biol. 442, 6 credits in genetics and/or plant breeding.

512. Principles of Fruit and Vegetable Storage (2-4) Principles involved in the maturation, storage, and senescence of fruits and vegetables, and their application. *Mr. Ritter*

514. Propagation and Improvement of Horticulture Plants (1-6) Biological factors affecting sexual and asexual propagation of plants; techniques in plant improvement; maintenance of propagation material.

517. Horticultural Seminar (1 per term) Review of current research publications in horticulture. Each student presents one or more reviews of assigned topics.

520. Genetics and Breeding Seminar (1 per term) Review of research and literature in genetics and breeding of horticultural crops.

524. Experimental Procedures in Horticultural Research (3) *Mr. Craig*

528. Problems in Fruit and Vegetable Processing (2-12) *Mr. McArdle*

HUMAN DEVELOPMENT AND FAMILY STUDIES (HD FS)

Joseph H. Britton, *In Charge of Graduate Programs in Human Development and Family Studies*
S-105E Henderson Human Development Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Baltes, Bortner, Britton, Danish, de Lissovoy, Ford, B. Guerney, Gunter, Harms, D. Harris, Hultsch, Knoll, Lewis, Looft, Nesselroade, Peters, Stein, W. Smith, Taylor, Urban, and Walcher.

Graduate Faculty: Associate Members Cohen, D'Augelli, Deutsch, Friedrich, Gage, Goldberg, L. Guerney, W. Harris, Hickey, Holstein, Huston, Kirchner, Kurtz, Neisworth, Nelson, Peterman, Ridley, Seward, R. Smith, Spanier, Vondracek, and Willis.

This interdisciplinary program is one of the graduate programs of the College of Human Development. It is administered through the Division of Individual and Family Studies. The program focuses on the developmental study of individuals, small groups, and families for the purposes of expanding basic knowledge and professional application. The perspective encompasses the individual life span, from infancy and childhood through later maturity and old age, as well as the full cycle of the family. For both individual and family, the perspective includes variations in functioning patterns and the use of resources; the impact of diverse social, economic, and cultural contexts upon behavior; and conditions and professional procedures which foster positive and constructive development. Emphasis is upon the integration of knowledge from various fields for understanding and developing skills for careers in research and scholarship, teaching, program planning and evaluation, and other professional services. The faculty includes persons primarily in the behavioral and social sciences.

The student's program is expected to include work assuring both breadth in the major field and depth within one of three program areas: family development, human development intervention, or individual development. Further specialization is possible in early childhood education, interpersonal relations, family economics and management, and educational gerontology.

Infant and preschool laboratories are operated as part of the teaching and research program. Each unit has observational facilities and rooms for study of individual and group behavior of children and adults. The Individual and Family Consultation Center provides facilities for the development and evaluation of educational programs for remediation of individual and family problems by professional and paraprofessional persons. The Institute for the Study of Human Development, the Center for Human Services Development, the Gerontology Center, the Center for Youth Study and Social Policy, the Pennsylvania Field Research Laboratory, and a simulation laboratory provide opportunities for participation in research and evaluation projects. Additional resources are available in other parts of the University.

A research and evaluation methodology core, required of all students, may be satisfied by selections from a variety of courses across the campus. Use may be made also of courses in other parts of the College and University to build substantive competence in the program. The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign languages. A minor or general studies group outside the major is required of all doctoral students.

Entering students should have at least 6 credits in the biological and physical sciences; 12 in the social sciences and, depending upon proposed area of emphasis, basic courses in sociology, psychology, and economics; and 6 in developmental and family studies. Students not meeting these requirements may be admitted with limited deficiencies to be made up concurrently with their graduate work.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission, which, with rare exception, will be for fall term only. Early application is required, and a special application to HDFS must be completed; additional information may be obtained from the professor in charge. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. The Graduate Record Examination is required of all applicants.

INDIVIDUAL AND FAMILY STUDIES (I F S)

410. Communities and Families (3)
411. The Helping Relationship (3)
413. Dysfunctions in the Developmental Process (3)
414. Resolving Individual and Family Problems (3)
415. Child Development and Family Relationships for Secondary Schools (3)
416. (C.S. 416) Consumer Role of Family (3)
418. Family Relationships (3)
419. Problems of Family Financial Management (3)
420. Problems in the Analysis of Individual Development (3-9)
424. Economic Conditions in Relation to the Family (3)
427. Conceptions in Development (3)
428. Infant Development (3)
429. Advanced Child Development (3)
430. Practicum in Preschool Groups (1-6)
432. Developmental Problems of Normal Children (3)
435. Developmental Transition to Adulthood (3)
439. Family Resource Management (2)
441. Organization Planning for Preschool Programs (3)
442. Home Management Experience (3)
445. (Psy. 445) Development Throughout Adulthood (3)
477. Analysis of Family Problems (2-9)
481. Developmental Programming for Preschool Children (3)

500. Nonthesis Research (1-9)

501. Seminar: Issues in the Study of Individual and Family Development (1-3) Reading, reports, and discussion of conceptual frameworks for multidisciplinary and developmental study of individuals and families.

504. Practicum in Program Development for Preschool Children (2-6) Investigation, analysis, and report on the design, development, and evaluation of a selected program for preschool children. Prerequisites: 6 credits of individual development and I.F.S. 430, 441.

506. Projects in Design and Evaluation of Programs for Preschool Children (2-4) Individual projects in the design, implementation, and evaluation of different teaching approaches with varying groups of children. Prerequisites: I.F.S. 504 and 3 credits in research methods.

508. Parental Education (1-6) Implementing educational and preventive programs for parents; discussion and evaluation of theory and techniques.

511. Modifying Conjugal Life (1-9) Conceptual foundations, research procedures, and practicum experience in teaching effective communication and problem-solving skills in the marriage relationship. Prerequisites: 6 credits in individual development or psychology and 3 credits in statistics.

512. Filial Relationship Modification (1-9) Theory, research, and practicum in teaching parents to resolve developmental problems in their own children. Prerequisites: 6 credits in individual development or psychology and 3 credits in statistics.

513. Group Procedures in Individual Development (1-6) Theory, research, and practicum experience in the use of group methods for promoting individual development in different age groups. Prerequisites: I.F.S. 411 and research methods or statistics.

515. Teaching Individual Development and Family Studies (1-6) Objectives, techniques, materials, and evaluation in teaching at the secondary and college level, and in adult and public education programs.

520. Seminar in Prenatal and Infant Development (1-6) Prenatal and infant development, with emphasis on multiple determinants of early development and their relationship to later behavior. Prerequisites: 6 graduate credits in individual development, psychology, or biological science and 3 credits in statistics.

522. Seminar in Dysfunctional Processes in Individual Development (1-6) Multiple processes involved in dysfunctional development in the individual across the life-span. Prerequisite: I.F.S. 413.

524. Theoretic Analysis of Family Economic and Managerial Behavior (3) Conceptual approaches and major contributions to the study of the organizational, managerial, and economic functions of the family. Prerequisite: I.F.S. 418 or 424 or 477.

525. Theories of Family Relationships (3) Assessment of the utility of major theories for empirical analysis of interpersonal interactions among family members. Prerequisite: I.F.S. 418.

528. Teaching Home Management (2-3) Development and evaluation of teaching objectives and methods in college and adult-level home management courses.

529. (Psy. 529) Seminar in Child Development (1-6) Readings and reports on recent findings in child development. Prerequisites: 6 graduate credits in child development, child psychology, or educational psychology, plus 3 in statistics.

530. Independent Study in Individual and Family Studies (1-9) Problems involving individual study. Prerequisite: instructor's approval of proposed study.

532. Field Projects in Individual and Family Studies (1-9) Supervised research or internship in human services program. Prerequisite: instructor's approval of proposed project.

536. (Psy. 536) Research Methods in Developmental Processes (3) Methodological issues in research on varying stages of development across the individual life-span. Prerequisites: 6 credits in individual development or psychology and a course in statistics.

539. SEMINAR IN ADOLESCENT DEVELOPMENT (1-6) Cultural, psychological, and biological aspects of the developmental transition to adulthood. Prerequisites: 6 credits in individual development or psychology and 3 credits in sociology and statistics.

543. MODIFICATION OF FAMILY MANAGERIAL PRACTICES (1-3) Conceptual issues, research, and practicum experience in assisting families in the solution of financial and managerial problems.

544. SEMINAR IN DYSFUNCTIONAL PATTERNS IN FAMILY ORGANIZATION (1-6) Processes of familial dysfunction and disorganization and their explanation in economic, social-psychological, and managerial terms. Prerequisite: I.F.S. 418 or 424 or Soc. 430.

545. FAMILIES AND SOCIOECONOMIC SYSTEMS (1-6) Functional interrelationships between families and social and economic systems. Prerequisites: I.F.S. 418, 424.

546. SEMINAR IN FAMILY RELATIONSHIPS (1-9) Interpersonal interaction within family systems throughout the life cycle. Prerequisite: I.F.S. 418.

549. (Psy. 549) DEVELOPMENTAL THEORY (3) Conceptual frameworks and major contributions to the study of individual development across the life-span. Prerequisite: 6 credits at the 400 level in individual development or psychology.

550. SEMINAR IN FAMILY ECONOMICS AND MANAGEMENT (1-6) Recent developments in the study of family economic and managerial practices.

579. SEMINAR IN ADULT DEVELOPMENT AND AGING (1-9) A seminar dealing with specific topics concerning adult development and aging. Prerequisites: I.F.S. 445 and statistics.

590. COLLOQUIUM (1-3)

597. SPECIAL TOPICS (1-6)

HUMANITIES (HUMAN)

NANCY M. TISCHLER, *Chairman, Humanities Program*
The Capitol Campus, Middletown, Pa. 17057

Degree Conferred: M.A.

Graduate Faculty: Senior Members Chen, Dordevic, Lear, Richman, Tischler, and M. Wolf.

Graduate Faculty: Associate Members Anderson, Eisenstein, Knight, McAree, and Patterson.

Defining humanities as the study of men and societies through examinations of their arts, this program aims at developing skills for the interdisciplinary study of art, music, literature, drama, and dance. Entering students are expected to have studied in at least two of these areas. A committee will meet with each student to determine his individual needs and arrange a program designed to help him develop essential skills for the analysis of works; for the classification of works into genres, periods, and schools; for the evaluation of works by applications of appropriate criteria; for the definition of individual, school, and period styles; and for the perception of relationships between various styles, media, periods, and cultures. For students who plan to teach in a junior college, there is also provision for an internship option.

A series of seven 500-level courses are designed to help a student develop a number of the program skills. In addition, his adviser may suggest he enroll in certain 400-level courses or in independent studies with qualified faculty.

To qualify for the M.A. in humanities, the student must demonstrate his competence in applying the methods of humanistic inquiry to a relevant subject area. His course work and independent study will help him to develop the appropriate skills and to acquire the necessary subject area knowledge, but the degree is not awarded in recognition of a set number of course credits having been compiled; the degree testifies that the recipient has cultivated the necessary skills of analysis and synthesis and has successfully completed a scholarly or creative master's production.

Ordinarily, a full-time student can expect to complete the program in three or four terms, a part-time student in six to nine terms.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

This program is available only at the Capitol Campus.

HUMANITIES (HUMAN)

500. RESEARCH METHODS (3) Study of the methods and materials of scholarship, compilation of bibliographies, writing of scholarly papers, and proper documentation.

501. PRESUPPOSITIONS IN THE HUMANITIES (3) Assumptions about knowledge, reality, and value which influence the humanist in his choice of ideas, methods, and modes.

502. PERENNIAL ISSUES IN THE HUMANITIES (3) Recurrent issues viewed in terms of their significance to the artist, historian, and the philosopher.

503. INTERRELATIONS IN THE HUMANITIES (3) An interdisciplinary study of the interdependence of aesthetic values in various art forms as they exist in cultural settings.

520. STUDIES IN STYLE (3) Study of prominent stylistic patterns, evaluating the essence of a style, and the varied responses of the artist and philosopher within a pattern.

525. STUDIES IN AESTHETICS (3) Study of certain techniques in the arts that presuppose certain aesthetic concepts and certain ideas that demand parallel form.

580. MASTER'S PRODUCTION (1-6) An original scholarly master's paper or creative production initiated by the student, supervised by an appropriate professor, and judged by a committee.

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

EDUCATION (ED)

520. SEMINAR IN JUNIOR COLLEGE TEACHING (3) The history of the two-year college, responsibilities of the teacher in the college organization, and methods of teaching.

550. INTERNSHIP IN JUNIOR COLLEGE (3) Teaching humanities courses in a two-year college under a master teacher, who will direct, criticize, and evaluate the intern.

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

INDUSTRIAL ENGINEERING (I E)

BENJAMIN W. NIEBEL, *Head of the Department of Industrial and Management Systems Engineering*
207 Hammond Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Draper, Ham, Lancaster, Niebel, Raphael, and Rosenshine.

Graduate Faculty: Associate Members Addison, Enscore, Freark, Guild, Keith, R. Olsen, Samuels, Thuering, and Zindler.

Graduate study and research are conducted in operations research-management science, production engineering, process design, systems engineering, and human engineering.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by an intermediate knowledge of one foreign language.

Graduates in industrial engineering, other engineering curriculums, and mathematics who present a 2.50 junior-senior average will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 230).

The Master of Engineering degree program is also offered at the King of Prussia Graduate Center.

INDUSTRIAL ENGINEERING (I E)

400. ENGINEERING FOR PRODUCTION (3)
402. ENGINEERING ECONOMY (3)
403. ENGINEERING ECONOMY AND STATISTICS (3)
404. MANAGEMENT SCIENCE (3)
405. LINEAR PROGRAMMING (3)
406. DESIGN OF PRODUCTION AND DISTRIBUTION SYSTEMS (3)
407. QUANTITATIVE METHODS FOR OPERATIONS RESEARCH (3)
408. HUMAN FACTORS ENGINEERING (3)
422a,b,c,d,e,f. INDUSTRIAL ENGINEERING PROBLEMS (2-12)
423. QUALITY CONTROL (3)
424. JOB EVALUATION (3)
425. INTRODUCTION TO OPERATIONS RESEARCH (3)
426. INDUSTRIAL AUTOMATION (3)
427. SOLIDIFICATION OF CASTINGS (3)
428. FOUNDRY ENGINEERING (3)
432. INTRODUCTION TO RELIABILITY ENGINEERING (1-3)
438. METAL CUTTING PRINCIPLES AND PRACTICE (3)

501. MANUFACTURING METHODS (2-8) Special projects including investigation; experimentation, design, and research of one or more special types of manufacture.

502. MANAGEMENT METHODS (3-6) Scientific management, including management controls and mathematical programming; research on special problems.

503. INDUSTRIAL RELATIONS (1-6) Study of human problems related to labor unions, hierarchy, specialization; analysis of organizational structure, policies, decision criteria, and communication systems.

504. ADVANCED QUANTITATIVE METHODS IN INDUSTRIAL ENGINEERING (3) Study of statistical and analytical decision models important in industrial engineering with emphasis on inference and testing of hypotheses. Prerequisites: Math. 62 and 3 credits in statistics.

506. Advanced Work Design and Measurement (3-9) Methods of research in motion and time study; critical analysis of current literature.

507. Operations Research: Scheduling Models (3) Scheduling models with simultaneous job arrival and probabilistic job arrival, network scheduling and scheduling simulation techniques. Prerequisites: I.E. 323, 402.

508. Operations Research: Inventory Models (3) A study of inventory theory, deterministic models, probabilistic models, multiproduct models in both the single and multiperiod modes. Prerequisite: I.E. 425.

509. Operations Research: Waiting Line Models (3) Waiting line models including models with infinite queues, finite queues, single and multiple servers under various priorities and disciplines. Prerequisite: I.E. 425.

510. Mathematical Programming (3) Study of advanced topics in linear programming including duality, decomposition, sensitivity analysis, parametric programming, and selected topics in mathematical progamming. Prerequisite: I.E. 405.

511. Experimental Design in Engineering (3) Statistical design and analysis of experiments in engineering; experimental models and experimental designs using the analysis of variance. Prerequisites: Math. 63 and 3 credits in statistics.

512. Graph Theory and Networks in Management Science (3) Prerequisite: I.E. 405.

513. Real Time Data Processing for Engineering Systems (3) Random access computers and communication components for real time systems; engineering systems simulation on digital computers. Prerequisite: Cmp.Sc. 102 or 410.

515. Complex Linear Flow Models (3) Application of complex linear flow models in engineering and management science, including static and dynamic system simulations. Prerequisite: I.E. 512.

516. Applied Stochastic Processes I (3) Prerequisites: I.E. 323, Stat. 418.

517. Applied Stochastic Processes II (3) Prerequisite: I.E. 516.

518. Plastic Deformation Processes (3) Study of the principles, theories, technology, design, and application of plastic deformation processes to shape metals. Prerequisite: undergraduate engineering degree.

528. Metal Cutting Theory (3) Study of the theory of metal cutting, contemporary and future problems of metal removal processes; critical analysis of current literature. Prerequisite: I.E. 438.

538. Experimental Investigations in Materials Processing (3) Experimental investigation on selected subjects in processing involving instrumentation, methods, and analysis. Prerequisite: I.E. 528.

596. Individual Studies (1-6)

JOURNALISM (JOURN)

Robert M. Pockrass, *In Charge of Graduate Programs in Journalism*
220 Carnegie Building

Degree Conferred: M.A.

Graduate Faculty: Senior Members Barnes and Harrison.

Graduate Faculty: Associate Members Dulaney, Froke, Goodwin, Norris, Pfaff, Pockrass, and Smith.

The program is flexible so as to meet the needs of students with various undergraduate or professional backgrounds. Candidates may select a 30-credit thesis program or a 36-credit nonthesis program. Generally, the thesis program is for those with an undergraduate major or

professional experience in journalism or communications, or for those who plan to pursue a doctoral degree. Its purpose is to provide an understanding of the structure and functions of communications in modern societies, and a strong minor in an appropriate field is normally required. The nonthesis program is usually selected by candidates with undergraduate majors in the humanities or social sciences and who now wish intensive professional training for a journalistic career. All candidates must take at least one course dealing with research in communications problems. Other requirements are tailored to the individual's background, interests, and goals.

Students who achieved at least a 2.50 junior-senior average in an appropriate undergraduate field of study will be considered for admission. Those with lower averages will be considered if their achievements since graduation recommend them. Applicants must submit an autobiographical statement of about 1,000 words indicating career objectives and type of program preferred.

JOURNALISM (JOURN)

401. Critics and Ethics of the Mass Media (3) *Mr. Harrison*
404. Mass Media in History (3)
405. International Mass Communications (3)
406. Evaluation and Uses of Mass Communications Research (3)
419. (Spch. 419) Comparative Broadcasting Systems (3)
421. Editorial Interpretation (3) *Mr. Harrison*
422. Cultural Aspects of the Mass Media (3) *Mr. Pockrass*
424. Public Affairs Reporting (3)
430. Journalism in the Schools (3-6)
436. (Soc. 436) Sociology of Opinion Formation (3)
442. Special Topics in Advertising (3)
443. Advertising Campaigns (3)
444. Advertising in Contemporary Society (3) *Mr. Norris*
460. Photography for the Mass Media (3) *Mr. Leos*
466. Public Relations Problems (3) *Mr. Gibbs*
468. Law of Mass Communications (3) *Mr. Smith*
470. Reporting of Contemporary Issues (3)
481. News Editing and Evaluation (3)
492. Public Affairs Broadcasting (3) *Mr. Farson*
499. Independent Study in Mass Communication (2-6) *Staff*

504. Seminar in the History of Mass Communication (3) *Mr. Harrison*

505. International Communication Problems (3) Legal and communications problems of the international flow of news and opinion; international press codes.

506. Introduction to Mass Communications Research (3) The scientific method; survey of basic concepts of theoretical and empirical research; variety of methodology; criteria for adequate research. *Mr. Barnes*

508. The Literature of Journalism (3)

510. Mass Communications Research Methods I (3) Design of research on processes and effects of mass communications; data analysis and hypothesis testing. Prerequisite: Journ. 506. *Mr. Barnes*

511. Mass Communications Research Methods II (3) Problems of bibliographical research; evaluation of sources and materials in mass communications history, biography, structure, ethics, and other areas. Prerequisite: Journ. 506.

513. Constitutional Problems of the News Media (3) Problems involving conflict between guarantees of press freedom in the First and Fourteenth Amendments and rights and privileges of others. *Mr. Harrison*

521. News Media and Public Opinion (3) Problems in the function, techniques, and responsibilities of press, radio, and television in forming and interpreting opinion. Prerequisite: Pl.Sc. 427. *Mr. Pockrass*

524. Government and Mass Communications (3) Problems of freedom of information; governmental efforts to control mass communication agencies; government news coverage; public information agencies. *Mr. Smith*

540. Seminar in Advertising Problems (3) *Mr. Norris*

545. Advertising and Consumer Behavior (3) Examination of theories of human behavior as they apply to the study of advertising's effects on consumer behavior.

585. Comparative Theories of Press Systems (3) Institutional structure and normative functions of press systems in modern societies, as shaped by prevailing world view and social organization. *Mr. Norris*

596. Individual Studies (1-6)

597. Special Topics (1-6)

LABORATORY ANIMAL MEDICINE (L A M)

C. Max Lang, *Chairman, Department of Comparative Medicine*
The Milton S. Hershey Medical Center
Hershey, Pa. 17033

Degree Conferred: M.S.

Graduate Faculty: Senior Members Andrews, Bullock, and Lang.

Graduate Faculty: Associate Members Hughes and White.

The department offers a postdoctoral program for veterinarians leading to the Master of Science degree with a major in laboratory animal medicine. Laboratory animal medicine is a specialty of veterinary medicine that is concerned with the biology of laboratory animals and their comparative relationships to man. Postdoctoral training in this discipline provides a broad, basic foundation upon which the individual can build a career in teaching and research in laboratory animal medicine and/or in the professional direction of research animal facilities. The program has a strong research-oriented base with emphasis on comparative medicine and pathology.

The program requires two years for completion. Basically, the first year consists of formal course work, while the second year is devoted mainly to research and the development of clinical skills and techniques. A student must have earned a minimum of 12 credits in a major subject, 6 credits in a minor subject, and 6 credits of thesis research in order to receive the graduate degree. Approved minors have been established in anatomy, behavioral science, biological chemistry, microbiology, pathology, pharmacology, and physiology.

Students with a 3.00 junior-senior average, with a doctor of veterinary medicine degree, and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

This program is offered only at The Milton S. Hershey Medical Center.

COMPARATIVE MEDICINE (C MED)

501. Biology and Care of Laboratory Animals (2) Presentation of the anatomic and physiologic characteristics of the commonly used laboratory animal species and their relation to biomedical research.

503. Laboratory Animal Genetics (2) Genetic principles applied to laboratory animals used for investigations of diseases that may be controlled or influenced by genetic factors.

505. Laboratory Animal Zoonoses (2) Experimentally induced, spontaneous, and infectious diseases transmissible between man and animals with special emphasis on etiology, differential diagnosis, and control.

507. Techniques of Laboratory Animal Experimentation (2) Techniques of drug administration, infusion, and collection of body fluids and materials; gnotobiology; use of radioisotopes and bioinstrumentation.

510. Animal Physiological Surgery (3) Selected operative procedures, demonstrating principles of physiology with modern biomedical instrumentation, will be followed through the postoperative period.

515. Experimental Surgery of Laboratory Animals (3) Surgical techniques, including nephrectomy and Goldblatt clamp, bladder and gastric pouches, bile duct cannulation, intraventricular operation, cardiac and cerebrovascular catheterization.

530. Diseases of Laboratory Animals, I (3) Physiological and pathological expressions of both infectious and metabolic-degenerative disease of rodents, with emphasis on diagnostic and control methods.

531. Diseases of Laboratory Animals, II (3) Physiological and pathological expressions of both infectious and metabolic-degenerative disease of nonhuman primates and other species of animals.

535. Comparative Pathology (3) Comparative pathologic characteristics of infectious and metabolic disease of animals and man.

540. Seminar (1 per term) Student and faculty discussions of organization and presentation of data on recent advances in selected topics of laboratory animal medicine.

570. Special Topics (1-6) Specialized training in advanced research techniques and current status of research in the various areas of laboratory animal medicine.

590. Research Problems (1-12) Research training will be given to enable the student to advance his knowledge about some aspect of laboratory animal medicine.

LINGUISTICS (LING)

Simon Belasco, *In Charge of Graduate Programs in Linguistics*
310 Burrowes Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Belasco, Borden, Brault, Brubaker, Cofer, Dalbor, Ebbinghaus, Hammer, Holtzman, Magner, Martin, Morrill, Palermo, Schmalstieg, and Sturcken.

Graduate Faculty: Associate Member Schnitzer.

A student majoring in linguistics may specialize in one of several flexible interdisciplinary graduate programs. The M.A. degree program includes general courses in historical linguistics, generative phonology and syntax, psycholinguistics, and acoustic phonetics. A candidate will also select, with the help of his graduate adviser, a coherent set of electives in a specialized area which may be a language or a related field. He will submit an acceptable thesis or paper and pass a written comprehensive examination.

In addition to the courses required for the M.A. degree in linguistics (or the equivalent), each candidate for the Ph.D. degree must take the following courses: Ling. 503 if he has selected Ling. 504 or vice versa, Ling. 505 (Seminar in Historical Linguistics), Spch. 520 (Seminar in Speech Science), and at least two 500-level courses in the structure, phonology, and history of a language or language family other than his native language if he specializes in a related area, and at least five 500-level courses in the related area. If he specializes in a language area, he

must take at least two 500-level courses in the structure, phonology, and history of a language or language family other than his native language or language area and at least five 500-level courses in his language area. The specialized area will be selected by the candidate with the approval of his doctoral committee. The doctoral comprehensive examinations will be both written and oral and will cover the synchronic and diachronic aspects of general linguistics as well as the candidate's specialized area. The thesis must represent a significant contribution to linguistic knowledge. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of either French, German, Spanish, or Russian and another major language related to the candidate's professional interests.

The minimum requirement for admission to an advanced degree program will normally be a B.A. degree in linguistics or an equivalent in any of the interdisciplinary subjects recognized as a specialized area.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

LINGUISTICS (LING)

400. Introduction to Transformational Grammar (3)
402. Historical Linguistics (3)
404. Generative Phonology (3)
413. (Spch. 413) Experimental Linguistics (3)
420. (Psy. 420) Advanced Psycholinguistics (3)
448. Language Variation (3)
449. Problems in Transformational Semantics (3)
451. (Greek 451) History of the Greek Language (3)
461. (Latin 461) History of the Latin Language (3)

500. Generative Linguistics (3) Types of grammatical rules and their interrelations; algorithm for assigning structural descriptions; evaluation procedure for selecting best compatible grammar.

503. Generative Syntax (3) Grammatical rules specifying well-formed strings; conditions on analyzability and assigning of structural descriptions; deviation from well-formedness. Prerequisite: Ling. 400.

504. Generative Phonology (3) Distinctive feature theory in the generative framework; articulatory and acoustic correlates; nonphonemic features. Prerequisite: Ling. 400.

505. Seminar in Historical Linguistics (3) Detailed study of some problem of historical linguistics, e.g., the laryngeal theory, Indo-European ablaut, etc. Prerequisite: one course in historical linguistics.

520. (Psy. 520) Seminar in Psycholinguistics (3) Consideration of theoretical and research issues relevant to psychological aspects of language sounds, syntax and semantics, and other cognitive support.

595. Seminar in Interdisciplinary Linguistics (3-12) Methods of research. Common and individual investigations in interdisciplinary fields of linguistics in consultation with one or more interdisciplinary instructors. Prerequisite: Ling. 400.

597. Special Topics (1-6)

MAN-ENVIRONMENT RELATIONS (M E R)

RAYMOND G. STUDER, *Director of the Division*
S-126 Henderson Human Development Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Arnold, Densmore, Lawton, Mann, Ritti, Studer, Vallance, and Wohlwill.

Graduate Faculty: Associate Members Coblentz, Everett, Griffin, Patterson, Powers, and Smith.

Graduate instruction and research opportunities are available in the application of tools and knowledge from the basic sciences to the understanding of man-environment systems and their development to meet human needs. This interdisciplinary program focuses upon issues related to the planning, design, management, and evaluation of environmental support systems for various human settings. Drawing heavily upon basic research in the behavioral sciences, this program deals extensively with effects of the man-made environment upon human biological, psychological, and social development and functioning.

Students may focus on either environmental-behavioral analysis or environmental-behavioral design and management, and may develop highly individualized courses of study to develop specialized competence. Courses within the division are organized to focus relevant knowledge from basic and applied disciplines on issues of environmental design, planning, management, and behavior analysis, emphasizing the interrelationships among them. Students are encouraged to participate in the course offerings of other programs within the University to complement and support this interdisciplinary focus.

The communication and foreign language requirement for the Ph.D. may be satisfied by options selected from designated areas including but not restricted to foreign languages. The thesis or paper option is available for the M.S. degree, subject to individual approval. Some preparation in statistics is expected; however, deficiencies in this and other areas may be removed concurrent with graduate studies.

Undergraduate preparation may be in relevant areas of the physical, behavioral or social sciences, or in environmental and urban studies. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 230).

FOOD SERVICE AND HOUSING ADMINISTRATION (FS HA)

402. FOOD SERVICE AND HOUSING LAYOUT AND DESIGN (3)
410. ADVANCED QUANTITY FOOD PRODUCTION (3)
412. FOOD AND BEVERAGE OPERATIONS (3)
435. FINANCIAL MANAGEMENT IN HOSPITALITY INDUSTRIES (3)
442. HOSPITALITY MERCHANDISING (3)
461. PERSONNEL FUNCTIONS IN FOOD SERVICE AND HOUSING ADMINISTRATION (3)
470. PROBLEMS IN FOOD SERVICE AND HOUSING ADMINISTRATION (3)

MAN-ENVIRONMENT RELATIONS (M E R)

400. PROBLEMS IN MAN-ENVIRONMENT RELATIONS (1-6)
408. INTERMEDIATE TEXTILES (4)
409. INTERMEDIATE TEXTILES LABORATORY (1-3)
410. DIMENSIONS OF CLOTHING BEHAVIOR (3)
415. FUNCTIONAL CLOTHING DESIGN (3-12)
416. WESTERN COSTUME DEVELOPMENT FROM THE RENAISSANCE TO THE PRESENT (3)
432. BEHAVIORAL ASPECTS OF MAN-ENVIRONMENT RELATIONS II (3)

442. Analytic Methods in Man-Environment Relations II (3)
452. Man-Environment Relations Laboratory II (3)
453. Man-Environment Relations Laboratory III (3)
471. Housing Space Related to Living Patterns (3)
472. Housing Problems and Policies (3)

500. Nonthesis Research (1-6)

501. Problems in Man-Environment Relations (1-9) Individual directed study, investigation and practice in selected aspects of man-environment relations.

502. Seminar in Man-Environment Relations (1-9)

503. Research Methods and Evaluation in Man-Environment Relations (1-9)

505. Environmental-Behavioral Programming, Design, and Management (3) Applications of findings in the behavioral sciences to environmental design and management strategies; empirical, theoretical, and methodological issues.

510. Psychological Foundations of the Study of Environment-Behavior Relations (3) Seminar relating the psychology of perception, cognition, motivation, personality, attitude formation, and psychological stress to aspects of the physical environment.

515. Environmental Systems Theory (3) An in-depth review of those elements of general systems theory relevant to the analysis and organization of man-environment settings.

516. Quantitative Methods in Environmental Management (3) The use of operations research and systems analysis in the modeling of man-environment systems. Prerequisite: M.E.R. 515.

520. Recent Developments in Textiles (3) Developments in fibers, yarns, fabrics, finishes; effects on use and care; discussions and reports based on current literature.

521. Clothing Behavior (3) Analysis and interpretation of clothing behavior through application of theories selected from the behavioral sciences.

522. Clothing Production, Distribution and Consumption Systems (3) Problems connected with manufacture and consumption of clothing; interrelation of textile and clothing trades with other industries.

523. Societal Determinants in Clothing and Textile Development (1-6)

525. Textile Technology (6)

534. (Stat. 534) Dynamic Programming (3) The study of the concepts underlying model-building and optimization of dynamic systems; applications to engineering, economic and environmental systems. Prerequisites: Stat. 418; I.E. 405 or Q.B.A. 451.

540. The Proximate Housing Environment (3) Evaluation of useful objects in respect to their form, function, and time; selection for exhibition.

541. Aesthetic Aspects of Housing (3) Approach based upon human needs with consideration of materials in the light of their use in home living.

MATHEMATICS (MATH)

PAUL AXT, *Head of the Department*
227 McAllister Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty: Senior Members Andrews, Armentrout, Axt, C. Ayoub, R. Ayoub, S. Chowla, Deutsch, Farrell, Fine, Glasner, Hahn, Hammer, Herman, Hunter, James, Kanwal, A. Krall, Lallement, Maserick, Montgomery, Morris, Olson, Petrich, Ribeiro, Rung, Wells, and Yood.

Graduate Faculty: Associate Members Brownawell, Chang, Huff, Kalmbach, Knight, Mack, Mansfield, McCammon, Parsons, Schneider, and Stevens.

Graduate courses in all the principal branches of mathematics are offered regularly each year. The department is prepared to direct research in a variety of fields, including various branches of analysis, algebra, topology, number theory, numerical analysis, applied analysis, algebraic geometry, and mathematical logic and foundations.

To be admitted to the Ph.D., D.Ed., or M.A. program without undergraduate deficiency, an applicant should have completed at least 18 credits in mathematics at the advanced undergraduate level (400 series or their equivalents). The undergraduate student is urged to take at least 6 credits in foundations of analysis (Math. 420-421), 6 in modern algebra (Math. 480-481, and 3 in topology (Math. 429) or their equivalents. These courses are essential preparation for the graduate program and, if they are taken after admission, a maximum of 6 credits may be counted toward an advanced degree.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

All Ph.D. students must take qualifying examinations in three fields of mathematics. Normally these examinations are taken before the beginning of the third year of graduate study. Recommendations for advancement to Ph.D. candidacy are based on these examinations together with performance in the first two years of study. The comprehensive examination is given after approximately 60 credits are earned and after the student has passed reading examinations in two languages chosen from French, Russian, or German. The Ph.D. student is also expected to enroll in advanced seminars.

Outstanding students who do not continue in the doctoral program may petition the department for further support in order to pursue a second master's degree in another area to which mathematics is applicable.

For the D.Ed. degree, a student must pass qualifying examinations in algebra and analysis and a reading examination in French, German, or Russian before he is allowed to take the comprehensive examination. In addition to the major thesis, the department requires participation in two terms of research seminar, but no minor thesis is required. The D.Ed. program is intended for college teachers. Three years of experience in college teaching is required for admission.

For the M.A. degree the department offers two options: (1) the thesis option requires 12 credits of approved 500-series courses in mathematics, 6-9 credits of thesis, sufficient credits in approved 400- or 500-series courses to make a total of 30 credits, and a final oral examination based on the thesis and general course material; and (2) the nonthesis option requires 18 credits of 500-series courses in mathematics with a grade of A or B, sufficient credits in approved 400- or 500-series courses to make a total of 30 credits, and a term paper on an approved topic in mathematics. No final examination is given in this option.

To be admitted to the M.Ed. program without undergraduate deficiency, an applicant should have completed at least 15 credits in mathematics at the intermediate level beyond calculus. The M.Ed. program does not require any 500-series courses, but the student is encouraged to select some at this level. Special courses have been instituted for the training of teachers. Among these are Math. 400, 401-402, 416, 425-426, and 470-471. These are acceptable for the satisfaction of credit requirements only for the M.Ed. degree.

Entering graduate students in mathematics for whom English is not the first language are required to have a score of at least 550 on the TOEFL (Test of English as a Foreign Language) examination. Furthermore, the results of this examination must be received by the Department of Mathematics at least six months prior to the requested date of admission to the Graduate School.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degree (see p. 230).

A brochure describing more fully the graduate program in mathematics is available from the Department of Mathematics.

MATHEMATICS (MATH)

400. Probability for Teachers (3)
401-402. Geometry for Teachers (3 each)
404. Theory of Numbers (3)
405. (A.M. 405) Fourier Series and Partial Differential Equations (3)
406. Topics in Theory of Numbers (3)
409-410. (Stat. 409-410) Introduction to Mathematical Statistics (3 each)
411. Finite Differences (3)
412. (Stat. 412) Introduction to Mathematical Statistics (3)
413-414. Mathematics of Science for Teachers (3 each)
416. Mathematical Logic for Teachers (3)
417. (A.M. 417) Tensor Analysis (3)
418. (A.M. 418, Stat. 418) Discrete Probability Theory (3)
420-421. Introduction to Analysis (3 each)
422. Algebraic Geometry (3)
423. Metric Differential Geometry (3)
425-426. Analysis for Teachers (3 each)
427. (Stat. 427) Discrete Stochastic Models (3)
428. (Phil. 428) Logical Theory (3)
429. General Topology (3)
430. Elementary Algebraic Topology (3)
431. (A.M. 431) Ordinary Differential Equations (3)
435. Axiomatic Set Theory (3)
441. (A.M. 441) Matrix Algebra (3)
452. (A.M. 452) Functions of a Complex Variable (3)
453. (Cmp.Sc. 453) Numerical Computations (3)
454. (Cmp.Sc. 454) Matrix Computations (3)
470-471. Algebra for Teachers (3 each)
472. Foundations of Geometry (3)
480-481. Introduction to Modern Algebra (3 each)
484. Linear Programs and Related Problems (3)
489. Mathematics Seminar (1-6)
490. Topics in Mathematics (3-9)
491. Topics in Applied Mathematics (3-9)

501-502. Theory of Functions of a Real Variable (3 each) Sets, metric spaces, measure and integration, Lp spaces and other function spaces, differentiation. Prerequisite: Math. 421.

503. Fourier Analysis (3) Fourier series and integrals, convergence and summability, theorems on Fourier coefficients, uniqueness properties. Prerequisite or concurrent: Math. 502.

505. Integral Equations (3) Fredholm and Volterra equations, and applications. Prerequisite: Math. 421.

507. Calculus of Variations (3) Prerequisite: Math. 421.

508-509. Complex Analysis (3 each) Analytic and meromorphic functions; Riemann's mapping theorem. Prerequisite: Math. 421.

511. Linear Algebra (3) Vector spaces and linear transformations, canonical representations, elementary divisors and invariant factors. Prerequisite: Math. 481 or 537.

515. Partial Differential Equations of Mathematical Physics (3) Methods of solution of selected elliptic, parabolic, and hyperbolic partial differential equations, with reference to physical application. Prerequisite: Math. 421.

517-518. (Stat. 517-518) Probability Theory (3 each) Measure theoretic foundation of probability, distribution functions and laws, types of convergence, central limit problem, conditional probability, special topics. Prerequisites: Math. 452, 501.

520. Projective Geometry (3) General study of the subject from the synthetic and analytic standpoint. Prerequisites: Math 472, 480.

523. Differential Geometry (3) Manifolds-differentiable structures, tangent spaces, connections, structural equations, Riemannian geometry. Prerequisite: Math. 429.

524. Advanced Complex Analysis (3) Topics include boundary behavior of analytic functions, bounded analytic functions, conformal mapping, theory of Riemann surfaces. Prerequisite: Math. 509.

525. Theory of Functions of Several Complex Variables (3-6) Topics include fundamental properties of holomorphic functions, complex analytic manifolds, integral representations, Cousin problems. Prerequisite: Math. 509.

526. Theory of Sheaves (3) Presheaves over topological spaces; defining sheaves two ways; Cech cohomology of presheaves; cohomology of sheaves; flasks; Lubkin's punctual cochains. Prerequisites: Math. 429; Math. 480 or 535.

527. Algebraic Geometry (3) Preschemes and proschemes; products; projective finite and affine presentation maps; projective quasicoherent sheaves; cohomology of quasicoherent sheaves over affine schemes. Prerequisite: Math. 526.

528. Uniform Spaces and Function Spaces (3) Uniform spaces, completion, compactifications, function spaces, metrization. Prerequisite: Math. 429.

529-530-531. Topology (3 each) Topological, product, compact, metric, and connected spaces; continuous functions; separation axioms, countability conditions, combinatory topology.

532. Theory of Sets (3) Formal development of set theory on a logical basis and related methodological problems; applications to the foundations of mathematics. Prerequisite: Math. 428.

535-536-537. Algebra (3 each) Basic theory of semigroups and groups, rings and modules, fields, lattices.

538. Commutative Algebra (3) Topics selected from noetherian rings and modules, primary decompositions, Dedekind domains and ideal theory, other special types of commutative rings or fields. Prerequisite: Math. 536.

539. Rings (3) Selected topics from the theory of rings. Prerequisite: Math. 536.

540. Valuation Theory (3) Selected topics from the theory of valuations on a field including completeness, extensions, ramification, local and global fields, adeles and ideles.

542-543. (Stat. 542-543) Statistical Distribution Theory (3 each) Random variables and expectations; discrete, continuous, univariate, multivariate, exact, and asymptotic distribution theory. Prerequisites: Math. 421; Math. 441 or 481.

547-548-549. Lie Theory (2 each) Topics selected from theory of topological semigroups, topological groups, lie groups, transformation groups. Prerequisite: Math. 531.

550. (Phil. 550) Foundations of Mathematical Logic (3) The nature of logical basis of mathematics; critical examination and development of the basic parts of logical calculus. Prerequisite: Math. 480 or 428.

552. (Cmp.Sc. 552) NUMERICAL ANALYSIS I (3) Interpolation; remainder theory; approximation of functions; error analysis; orthogonal polynomials; approximation of linear functionals; functional analysis applied to numerical analysis. Prerequisites: Math. 420, 453.

553. (Cmp.Sc. 553) NUMERICAL ANALYSIS II (3) Eigenvalue and eigenvector determination; numerical solution of integral equations and ordinary differential equations with error and stability analysis. Prerequisites: Math. 420; Math. 454 or 481.

554. (Phil. 554) LOGIC AND METAMATHEMATICS I (3) Completeness, Löwenheim-Skolem, Herbrand, and compactness theorems; first-order theories; categoricity, elimination of descriptions; decidability; algebraic and geometric applications. Prerequisite: Math. 428.

556. RECURSION THEORY (3) Recursive functions; normal form, enumeration and separation theorems; partial recursive functions; recursion theorems; special recursive functions; alternate formulations; related topics. Prerequisite: Math. 428.

557. (Phil. 557) LOGIC AND METAMATHEMATICS II (3) Arithmetization; Gödel and Tarski incompleteness theorems; undecidability results; Gentzen-type systems and consistency results. Prerequisite: Math. 428.

558-559. (Stat. 558-559) THEORY OF STOCHASTIC PROCESSES (3 each) Stationary, independent, and orthogonal processes; discrete and continuous Markov processes; martingales and semi-martingales applications. Prerequisite: Math. 518.

560-561. THEORY OF DIFFERENTIAL EQUATIONS (3 each) Topics selected from existence and uniqueness of solutions of differential systems, Sturm-Liouville systems, eigenvalue problems, integral operator solution. Prerequisites: Math. 72 or 83 or 100; Math. 508.

562. THEORY OF SPECIAL FUNCTIONS (3) Topics include asymptotic expansions; Riemann-Papperitz and Trusdell's F equations; orthogonal polynomials; generating, beta, zeta, hypergeometric, Bessel, Legendre, elliptic functions. Prerequisites: Math. 72 or 83 or 100 and either Math. 420 and 452, or Math. 508.

563. (Cmp.Sc. 563) APPROXIMATION THEORY (3) Approximation in normed spaces; existence, uniqueness, characterization, computation of best approximations; error bounds; degree of approximation; approximation of linear functionals. Prerequisites: Math. 453, 501.

564. (Cmp.Sc. 564) NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS (3) Numerical solution of initial and boundary-value problems; eigenvalues and eigenfunctions; errors, stability, and convergence. Prerequisite: Math. 552.

565. FUNCTIONAL ANALYSIS (3) Theory of Banach and Hilbert spaces, including functionals and operators, and related topics. Prerequisite: Math. 502.

570. SPECIAL TOPICS IN GEOMETRY (3-12)

571. SPECIAL TOPICS IN ANALYSIS (3-12)

572. SPECIAL TOPICS IN ALGEBRA (3-12)

573. SPECIAL TOPICS IN APPLIED MATHEMATICS (3-12)

574. SPECIAL TOPICS IN FOUNDATIONS OF MATHEMATICS (3-12)

575-576. MATHEMATICS SEMINAR (1-6 each) Selected topics from recent mathematical developments.

577. SPECIAL TOPICS IN PROBABILITY (3-12) Special topics in probability which are not offered regularly but which are of special interest to faculty and students.

578. SPECIAL TOPICS IN TOPOLOGY (3-12)

579. (Cmp.Sc. 579) SPECIAL TOPICS IN NUMERICAL ANALYSIS (2-12)

580. SPECIAL TOPICS IN NUMBER THEORY (2-12)

581-582. GROUP THEORY I, II (3 each) Selected topics from group theory including Abelian, solvable, nilpotent, and free groups, Sylow theorems, and group extensions and representations. Prerequisite: Math. 535.

583. HOMOLOGICAL ALGEBRA (3) Modules, diagrams, functors, homology of complexes, resolutions, cohomology of groups, tensor and torsion products. Prerequisite: Math. 536.

584-585-586. ALGEBRAIC TOPOLOGY (2 each) Development of singular and Cech homology and cohomology theories; homotopy and cohomotopy theories. Prerequisite: Math. 531.

587-588-589. POINT SET TOPOLOGY (2 each) Topics selected from point set topology including upper semicontinuous and continuous decompositions, theory of continua, dimension theory. Prerequisite: Math. 531.

592-593-594. NUMBER THEORY (3 each) Congruences, quadratic residues, arithmetical functions, Dirichlet's theorem, prime number theorem, classical multiplicative ideal theory, partitions, valuations and p-adic numbers, divisors. Prerequisite: Math. 480. Prerequisite or concurrent: Math. 508.

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

NOTE: *Courses in Applied Mathematics, Computer Science, and Statistics are listed separately.*

MATHEMATICS (MATH)

HELMUT E. WEBER, *In Charge of Graduate Program in Mathematics*
King of Prussia Graduate Center, King of Prussia, Pa. 19406

Degree Conferred: M.Ed.

Graduate Faculty: Associate Members Callahan, Duncan, and Llorens.

The program is offered specifically to permit teachers in the area to pursue advanced studies through evening classes while employed in teaching. Courses offered for the program are established and controlled by the resident departments at the University Park Campus.

Credit requirements may be satisfied by completing a minimum of 18 credits in approved mathematics courses, a minimum of 6 credits in approved mathematics and science courses, and a minimum of 6 credits in approved education courses. In addition, a term paper is required. All requirements must be met within six years or seven consecutive summers.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. An applicant must have a bachelor's degree and have completed 27 credits in mathematics including at least 15 credits at the intermediate level beyond calculus. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Further details concerning this program may be obtained by writing directly to the King of Prussia Graduate Center.

MECHANICAL ENGINEERING (M E)

DONALD R. OLSON, *Head of the Department*
207 Mechanical Engineering Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Brickman, Brighton, Cunningham, Di Ilio, Faeth, Heinsohn, Lestz, McLaughlin, Meyer, Moroz, Olson, Reethof, Schmidt, Shearer, and Wolgemuth.

Graduate Faculty: Associate Members DeCarolis, Henry, Kuo, Matsumoto, Nelson, Park, Parke, and Wambold.

Graduate programs and research facilities are available in thermodynamics and combustion, heat transfer, fluid mechanics, dynamic system analysis, mechanical design, biomedical engineering, automatic controls, and fluid amplifiers. Air pollution control, automotive safety, designing for noise control and for reliability also provide many research and design opportunities.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by an in-depth study of one foreign language (9-12 credits) or by demonstrating competence in translating the technical literature in two foreign languages; or by taking three or more courses (minimum of 9 credits) of a nontechnical nature in a single area of study appropriate and related to the student's career orientation.

A student working toward an M.S. degree may choose one of the following options: (1) a minimum of 24 course credits plus 6 thesis credits (M.E. 600) culminating in the submission of a thesis to the Graduate School or (2) a minimum of 30 course credits plus submission of a Ph.D. thesis research proposal, provided the student has passed the candidacy examination.

The entering student must hold a bachelor's degree in engineering or physical science. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

MECHANICAL ENGINEERING (M E)

401. MECHANICAL ENGINEERING (3-12)
402. AIR CONDITIONING AND LIFE SUPPORT SYSTEMS (3)
403. ROCKET PROPULSION (3)
405. SMALL PARTICLE TECHNOLOGY (3)
409. GAS TURBINES (3)
410. POWER PLANTS (3)
411. REFRIGERATION (3)
412. HEAT TRANSFER (3)
413. INTERNAL COMBUSTION ENGINES (3)
414. ENGINEERING ANALYSIS OF THERMAL SYSTEMS (3)
415. ENGINEERING ANALYSIS FOR MECHANICAL DESIGN (3)
417. THEORY OF ENGINEERING INSTRUMENTS (3)
418. PRINCIPLES OF TURBOMACHINERY (3)
421. (Aersp. 421) INTERMEDIATE VISCOUS FLOW (3)
450. DESIGN OF MACHINE TOOLS (3)
451. ADVANCED MACHINE DESIGN PROBLEMS (3)
452. DESIGN ANALYSIS (3)
455. AUTOMATIC CONTROL SYSTEMS (3)
458. NOISE CONTROL IN MACHINERY (3)
460. RELIABILITY CONCEPTS IN DESIGN (3)
470. INTRODUCTION TO AIR POLLUTION CONTROL (3)
472. ENGINEERING AND ADMINISTRATION OF AIR POLLUTION CONTROL (8)

503. THERMODYNAMIC PROCESS ANALYSIS (3) Development of equations governing separate processes in complete machines to give basic system parameters and characteristics; transient processes; irreversible effects.

504. ADVANCED ENGINEERING THERMODYNAMICS (3-6) Pure and applied thermodynamics including its application to advanced engineering problems; collateral reading and discussion of the classical works on the subject.

506. SELECTED TOPICS IN MECHANICAL ENGINEERING (1-12) Advanced courses adapted to the individual requirements of graduates in mechanical engineering.

512. HEAT TRANSFER — CONDUCTION (3) One- and two-dimensional conduction heat transfer for steady state and transient systems with varying boundary conditions.

513. HEAT TRANSFER — CONVECTION (3) Laminar and turbulent flow heat transfer in natural and forced convection systems.

514. HEAT TRANSFER — RADIATION (3) Thermal radiation fundamentals; specular and diffuse systems; differential and integral methods; numerical techniques; industrial applications.

519. COMPRESSIBLE FLUID FLOW (2-4) Two-dimensional subsonic flow; similarity rules; theory of characteristics; supersonic and hypersonic flows; nonsteady flow; oblique shock waves.

521. ELECTROMAGNETIC AND THERMODYNAMIC FLOW SYSTEMS (3) Thermodynamic equations for flow of reacting and nonreacting fluids in electromagnetic fields; applications to engineering problems.

522. BOUNDARY LAYER AND SEPARATED FLOWS (3) Behavior of viscous fluids, with emphasis on boundary layer and separation effects in internal flow.

540. SIMULATION OF MECHANICAL ENGINEERING PHENOMENA (3) Analog and numerical methods for simulation of problems in thermodynamics, heat transfer, fluid mechanics, diffusion, and machine dynamics.

552. ADVANCED DYNAMICS OF MACHINES (3-6) Linear and torsional vibrations in and balancing of rotating and reciprocating machinery; exact analysis of stresses produced by these and other dynamic forces in machine parts. Prerequisites: E.Mch. 12, M.E. 54.

553. FRICTION AND LUBRICATION (3) Sliding and rolling surface phenomena; hydrostatic, hydrodynamic, and magnetohydrodynamic lubrication theory; design and control of gas and fluid lubricated bearings.

555. AUTOMATIC CONTROL SYSTEMS (3) Advanced problems and techniques in the design of automatic control systems with emphasis on stability, controller design, and optimum performance. Prerequisite: M.E. 455.

556. ADVANCES IN CONTROL SYSTEMS ANALYSES (3) Control system theory and applications of newly developed theory to engineering systems; nonlinear systems, distributed systems, state-space methods. Prerequisite: M.E. 555.

557. MECHANISM SYNTHESIS (3) Geometrical and algebraic methods for synthesizing planar and spatial mechanisms, dynamics of spatial mechanism.

558. FLUID CONTROL SYSTEMS (3) Systems elements, simplified models, analysis of interacting elements, instrumentation; computer-aided case study, and experimental investigations. Prerequisite: M.E. 455.

560. PROBABILISTIC METHODS IN MACHINE DESIGN (3) Reliability determination of machines for various types of interfering stress and strength probability functions. Probabilistic life consumed modeling. Prerequisites: Math. 409 or M.E. 460 or I.E. 323; M.E. 42, 54.

571. AIR POLLUTION SEMINARS (1-2) Weekly seminars featuring the contributions of many different disciplines to the solution of air pollution and other environmental problems.

580. INVESTIGATION PROJECTS (2-6) Special experimental studies or investigations in mechanical engineering, adapted to individual requirements.

METALLURGY (METAL)

FRANK F. APLAN, *In Charge of Graduate Programs in Metallurgy*
209 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Aplan, Bitler, Healy, Hoke, Muan, Ryba, and Simkovich.

Graduate Faculty: Associate Members Pickering and Thrower.

This program is one of the options in which a graduate student in the Department of Material Sciences can receive an advanced degree. A student may specialize, through both course work and research, in the science and engineering aspects of chemical, physical, or mechanical metallurgy.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language together with courses from other designated areas.

Suitable preparation for graduate study in this program may be found in one of the material sciences such as ceramic science, fuel science, metallurgy, or solid state science; in engineering fields such as chemical or mechanical engineering; in basic physical sciences such as chemistry or physics; or in earth sciences such as geochemistry and mineralogy. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

METALLURGY (METAL)

401. METALLURGICAL PROCESSES AND KINETICS (3)
402. ELECTROMETALLURGY, HYDROMETALLURGY, AND CORROSION (3)
403. ANALYTICAL METALLURGY
404. PYROMETALLURGY (3)
405. PHYSICAL METALLURGY (3)
406. METALLOGRAPHY (3)
407. METALLURGICAL ENGINEERING I (3)
408. METALLURGICAL ENGINEERING II (3)
410. METALLURGICAL INVESTIGATIONS II (3)
412. SOLID-STATE METALLURGY (3)
420. PARTICULATE SYSTEMS IN MINERAL PROCESSING (3)
421. PARTICLE TECHNOLOGY LABORATORY (1-3)
423. RECENT DEVELOPMENTS IN MINERAL PROCESSING (3)
424. (Min.E. 424) COAL PREPARATION (3)
425. INTERFACIAL PHENOMENA AND FLOTATION (3)
459. METALLURGICAL APPLICATIONS FOR ENGINEERS (3)
460. POLLUTION CONTROL IN THE MINERAL PROCESS INDUSTRIES (3)

501. METALLURGICAL PROBLEMS (1-6 per term) Independent study of special problems in metallurgy.

502. SEMINAR IN METALLURGY (1-6) Conferences, reading, reports, and special lectures.

508. KINETICS OF PHASE TRANSFORMATIONS (3) Application of statistical mechanics and absolute rate theory to kinetics of phase transformations, including diffusion, nucleation, and growth rates. *Mr. Bitler*

509. INTRODUCTORY THEORETICAL PHYSICAL METALLURGY (3) Quantum mechanics and its application to solid-state theory; introduction of Schroedinger's equation, its solutions, free-electron model, band model. *Mr. Bitler*

510. Magnetic and Transport Properties of Materials (3) Treatment of the magnetic and transport properties of solids by quantum mechanics with applications to practical alloy development. Prerequisite: Metal. 509. *Mr. Bitler*

511. Advanced Physical Metallurgy (3) Physical metallurgy of an advanced nature; consideration of solid state bonding, crystal structure, alloy constitution. Prerequisite: Metal. 509. *Mr. Ryba*

513. Advanced Chemical Metallurgy I (3) Application of thermodynamics and kinetics to the heterogeneous metallurgical processes of oxidation, reduction, smelting, and refining. Prerequisites: Chem. 452, Metal. 301, 402, 404. *Mr. Healy*

514. Dislocation Theory (3) Self and interaction energies of dislocations and other defect structures; dislocation motions and their relation to mechanical properties. *Mr. Bitler*

515. Corrosion of Metals (3) Phenomena and theories of metallic corrosion; principles of alloy selection for engineering and structural uses in corrosive environments. *Mr. Pickering*

516. Flow and Fracture of Solids (3) Phenomenological and theoretical treatment of flow and fracture in solids. Prerequisites: Metal. 511, 514. *Mr. Hoke*

518. Heterogeneous Equilibria at High Termperatures (2-3) Treatment of high-temperature equilibria in metal and oxide systems involving crystalline, liquid, and gas phases. Prerequisite: Metal. 513. *Mr. Muan*

519. Advanced Chemical Metallurgy II (3) Application of thermodynamics and kinetics to precipitation of nonmetallic and metallic phases from liquid and solid metals at elevated temperatures. Prerequisite: Metal. 513. *Mr. Healy*

520. Foundry Metallurgy (3) Physical-chemical considerations of the liquid state, solidification, and the solid state as applied to casting of metals and alloys. Prerequisites: Metal. 511, 513.

522. Solid-Phase Reactions in Metals (3) Mechanisms and rate determining factors in solid-phase reactions in metals; diffusion processes, nucleation theory, precipitations from solid solution, eutectoid decomposition and order-disorder phenomena. Prerequisites: Metal. 508, 511. *Mr. Bitler*

535. (E.Mch. 535) Crystal Defects and Mechanical Response (3) Mechanical responses of crystalline solids containing point, line, and interfacial defects; elastic and plastic responses. Prerequisite: Metal. 514 or E.Mch. 414.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in metallurgical studies are listed under Materials Science.*

METEOROLOGY (METEO)

Alfred K. Blackadar, *Head of the Department*
503 Deike Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Blackadar, Dutton, Hosler, and Panofsky.

Graduate Faculty: Associate Members Anthes, Cahir, Fraser, Lavoie, Norman, Olivero, J. Pena, R. Pena, and Thomson.

Candidates may specialize in the study of problems in either theoretical or applied meteorology including such areas as cloud physics, various phases of dynamic meteorology and geophysical fluid dynamics including turbulence and atmospheric circulation, numerical modeling, macro- and microclimatology, synoptic meteorology, or meteorological instrumentation. The department also encourages interdisciplinary studies in such fields as agricultural meteorology, biometeorology, water resources, air pollution, and fluid mechanics.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language (French, German, or Russian). The thesis or paper option is available for the M.S. degree.

Requirements for admission include mathematics through differential equations and one year of college physics. Undergraduate study of meteorology is not required for admission. Special programs are available to encourage the graduate study of meteorology by all students with strong backgrounds in mathematics, physics, or engineering. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

METEOROLOGY (METEO)

400. Meteorology for Teachers (3)
401. Physical Climatology for Teachers (3)
403. Science Projects in Meteorology (1)
404. Motions of the Atmosphere and Oceans (3)
407. Elements of Physical Oceanography (3)
411. Introduction to Synoptic Meteorology (3)
418. Introductory Physics of the Upper Atmosphere (3)
420. Tropical Meteorology (3)
430. Introduction to Synoptic Meteorology Laboratory (3)
431. Synoptic Meteorology Laboratory I (3)
432. Synoptic Meteorology Laboratory II (2-10)
433. Advanced Synoptic Analytical Techniques (3)
434. Application of Meteorological Satellite Data to Analysis and Forecasting (3)
443. Physical Meteorology (3)
445. Hydrology for Meteorologists (3)
450. Applications of Statistics to Meteorology (3)
451. Introduction to Dynamic Meteorology (3)
452. Hydrodynamics of the Atmosphere (3)
453. Atmospheric Thermodynamics (3)
461. Theory of Meteorological Instruments (3)
472. Physical and Dynamic Climatology (3)
473. Introduction to Micrometeorology (3)

500. Meteorological Seminar (1-3) Discussion of meteorological reports and papers; scientific outlook. Prerequisites: Meteo. 411, 451.

502. Selected Topics of Advanced Meteorology (1-3 per term) Current problems in meteorology. Prerequisite: a minimum of 15 credits in meteorology.

503. Atmospheric Turbulence (3) Atmospheric diffusion, heat conduction, friction, and evaporation; statistical properties of turbulence.

505. Bioclimatology (2) Climatic phenomena in their relation to life. Prerequisite: Meteo. 472.

506. Advanced Meteorological Analysis (2-6) Physical analysis of atmospheric phenomena; synoptic analysis of weather phenomena for advanced students.

507. Dynamic Oceanography (2) Physical properties of sea water; heat balance of the oceans; theory and observations of ocean currents, waves, and tides.

508. Physics of the Upper Atmosphere (2) Temperature distribution, composition, and electrical characteristics of the upper atmosphere; theories of aurora and light of the night sky.

509. Theoretical Climatology (2) Theory of latitudinal, annual, and diurnal temperature changes; theories of climatic changes, microclimate.

510. Cloud Physics (2) Current theories on phase changes in clouds and mechanisms responsible for precipitation; techniques of cloud modification and control.

511. Cloud Dynamics (2) Study of the structure of cloud-scale motions; numerical models of cumulus clouds; thunderstorms, hailstorms, tornadoes, mesoscale organization of convection. Prerequisite: Meteo. 453.

520. Indirect Atmospheric Probing (3) Analysis and description of measurements made with radar and bistatic radio, optical and acoustic systems used for indirect atmospheric sounding. Prerequisite: Meteo. 443.

545. Snow Hydrology (2) Importance of snow in meteorology and the hydrologic cycle; snow properties, metamorphism, prediction of snowmelt runoff, and snow management potentials.

550. Atmospheric Motions (3) Fundamental properties and conservation requirements of the hydrodynamic equations; elements of advanced dynamic meteorology and applications to atmospheric dynamics. Prerequisite or concurrent: A.M. 451.

551. Atmospheric Wave Motion (2) From classical and physical hydrodynamics to the numerical prediction of wave motion in a baroclinic atmosphere. Prerequisite: Meteo. 452.

552. Advanced Atmospheric Dynamics (2) Numerical prediction models, general circulation, thermal and gravitational tides in a spherical shell, and empirical orthogonal functions of statistical forecasting. Prerequisite: Meteo. 551.

553. Energetics of Atmospheric Motion (2) Theoretical investigation of the conversions of energy in the atmosphere; maintenance of the general circulation. Prerequisite: Meteo. 452.

555. Atmospheric Diffusion (2-3) Dispersion of atmospheric contaminants; experiments, theory and practical implications for air pollution problems. Prerequisite: 3 credits of statistics.

561. Chemistry of the Atmosphere (2) Fundamental knowledge of chemical characteristics of atmospheric components and transformations, in connection with cloud microphysics, circulation, and air pollution. Prerequisite: 3 credits in chemistry.

597. Special Topics (1-6)

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in meteorological studies are listed under Materials Science.*

MICROBIOLOGY (MICRB)

Robert W. Bernlohr, *Head of the Department*
S-101 Frear Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Casida, Ceglowski, Joys, Lindstrom, Ludwig, Tershak, and Zimmerman.

Graduate Faculty: Associate Members Brenchley, Docherty, Fung, Kolenbrander, Pootjes, and Zarkower.

Specialized areas of study in microbiology include cytology, ecology, food, genetics, immunology, physiology, virology (both animal and bacterial), and environmental and industrial microbiology. There is opportunity for cooperative research with other departments.

The communication and foreign language requirement for the Ph.D. may be satisfied by intermediate knowledge of one foreign language (French, German, or Russian).

Prerequisites for admission are 16 credits in inorganic and organic chemistry, 6 in physics, 8 in microbiology, and mathematics through calculus. Admission may be granted with deficiencies up to 8 credits, to be made up while pursuing graduate work. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The

best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. A satisfactory score on the Graduate Record Examination is required for admission.

MICROBIOLOGY (MICRB)

400. Introductory Environmental Microbiology (4)
401. Advanced Bacteriology (4)
407. Problems in Microbiology (1-12)
410. Immunology and Serology (3)
411. Survey of Microbiology (1 per term)
413. Microbial Soil Ecology (3)
414. Food Microbiology (2-4)
415. Introduction to Animal Viruses (2-4)
416. Industrial Microbiology (2-4)
417. Epidemiology (2)
418. Bacterial Viruses (2-4)
470. General Microbiology for Science Teachers (4)

507. Seminar (1 per term) Reports on current fields of research.

508. Bacterial Physiology (2-4) Contributions of environment, finestructure, and metabolism to the functioning cell. Prerequisite: 6 credits of biochemistry.

510. Experimental Immunology (4) The nature of the immune response with emphasis on modern concepts and techniques. Students should have some background in immunology.

511. Special Topics in Microbiology (1-6)

512. Microbiological Methods (1-6) Practice in special laboratory techniques of modern microbiology.

516. Bacterial Genetics (2-4) Mechanisms of variation in microorganisms including mutation, adaptation, sexual recombination, transduction, and transforming factors. Prerequisites: 3 credits each in microbiology and genetics.

520. Biochemical Virology (2) Role of enzymes and nucleic acids in virus synthesis. Regulation of virus reproduction in animal and bacterial cells. Prerequisite: 6 credits of biochemistry.

529. (C.E. 579) Aquatic Microbiology (3) Ecology and physiology of microorganisms of inland waters, estuaries, and oceans; microbiology of wastewater treatment. Prerequisite: introductory microbiology.

MICROBIOLOGY (MICRO)

Fred Rapp, *Chairman of the Department*
The Milton S. Hershey Medical Center
Hershey, Pa. 17033

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Member Rapp.

Graduate Faculty: Associate Members Christensen, Funk, Glaser, Hyman, Kreider, Lausch, Lipton, and Marquez.

This program is oriented to the study of the general areas of bacteriology, virology, and immunology. Active research programs exist in a variety of subdivisions of these disciplines. Some areas emphasized include the replication and structure of viral nucleic acids, the role of

viruses in tumor formation, viral latency in both bacterial and mammalian systems, tumor immunology, and electron microscopy of viruses and virus-infected cells.

The communication and foreign language requirement may be satisfied by demonstrating competence in one foreign language such as French, German, or Russian. Alternatively, with special permission, courses which enhance communication skills can be substituted for the foreign language requirement.

Qualified students with undergraduate preparation in either the biological, biochemical, or physical sciences may apply. An adequate background in biology, chemistry, and mathematics and a 3.00 junior-senior average are desirable. Programs leading to advanced degrees will be tailored to the background and the needs of the individual candidate.

The best-qualified applicants will be accepted on a space-available basis. Applications should contain two letters of recommendation and a brief personal essay summarizing the background and professional goals of the applicant.

This program is offered only at The Milton S. Hershey Medical Center.

MICROBIOLOGY (MICRB)

551. Medical Microbiology (3) Principles of microbiology; viruses, rickettsia, bacteria, and fungi as agents of disease. Introduction of microbial genetics, epidemiology, and immune mechanisms.

552. Medical Microbiology Laboratory (2) Laboratory exercises to augment Micrb. 551. Laboratory tests used to characterize microoganisms and to aid in diagnosis of disease.

553. Science of Virology (3) Replication of viruses and effect on host, including transfer of genetic information, immunology, and oncogenic properties of viruses.

554. Immunology of Infection (3) The nature of antigens and antibodies, humoral and cellular immune response governing histocompatibility, transplantation, tolerance, and autoimmune disease.

555. Microbial Physiology and Metabolism (3) Physiology and comparative biochemistry of microorganisms, especially human pathogens. Concepts of genetic regulation and balanced growth applied to cell replication.

556. Microbial Genetics (3) Genetics of microorganisms, including gene mapping, lysogeny, information transfer, and viral carcinogenesis.

557. Electron Microscopy (3) The application of electron microscopy to microbiology, including specimen preparation, use of the electron microscope, and photography. Prerequisites: admission to the medical or graduate program and permission of instructor.

570. Topics in Microbiology (2 per term) Lectures and seminars concerning current developments in microbiology.

571. Seminar in Microbiology (1 per term) Weekly presentations by faculty and postdoctoral and predoctoral trainees of current work in the department.

572. Literature Reports (1 per term) Weekly analysis of current literature in microbiology.

573. Selected Readings (2 per term, maximum of 6) Supervised reading program of pertinent literature in microbiology and related scientific fields.

580. Laboratory Experiments in Microbiology (2-6 per term) Laboratory exercises in microbiology, including cell culture, microscopy, radioisotope and other biochemical procedures, serology, and genetic techniques.

581. Special Projects in Microbiology (2-6 per term) Research projects carried out by graduate students under supervision of a member of the faculty.

MINERAL ECONOMICS (MN EC)

JOHN D. RIDGE, *Head of the Department*
104 Mineral Sciences Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Gordon, Ridge, and Schenck.

Graduate Faculty: Associate Member Tilton.

The program in mineral economics prepares students for careers in mineral industries management, administration, or economic analysis and planning. Students may specialize in such areas as commodity analysis (energy, metals, or nonmetals); resource economics (mineral policy or area studies); industrial economics (administration, market research, or financial matters); geostatistical and economic analysis of exploration and exploitation problems; or operations research and statistics (resource allocation, forecasting, or decision making).

Two related but distinctly different general programs for obtaining the M.S. and Ph.D. degrees are available, the one chosen depending on the education and practical experience of the candidate. One program is for students whose background is in the mineral industries and who wish to combine their scientific training with an understanding in depth of the methods by which economics can aid in solving problems in mineral industries exploration, exploitation, and processing. Requirements for admission to this program are 24 credits in chemistry, physics, mathematics, or statistics; 12 in the earth sciences; 9 in economics, mineral economics, commerce, business administration, or industrial management; and 6 in engineering subjects.

The second program is for students whose background is in economics and whose training and experience have given them an interest in applying their economic skills to the solution of mineral industries problems. Requirements for admission to this program are 12 credits in economics, mineral economics, and business administration; 6 in geological sciences; and 9 in mathematics and statistics.

The differences between the programs followed by these two groups of students will affect every aspect of their graduate programs — thesis work, required mineral economics courses, and elective selection. In all cases, the choices among courses and the emphasis within courses taken would be determined by the background of the student, the mineral industries-based program placing equal weight on the technical and economic aspects of mineral economics and the economics-based program placing more weight on the economic than on the technical features of the problems considered.

In addition to the normal degree requirements of the Graduate School, candidates for the M.S. degree must write a thesis and defend it orally. Doctoral candidates in the mineral industries-based program must complete at least 15 credits in economics (including courses used for admission). Doctoral candidates in the economics-based program must complete at least 12 credits in the earth sciences or mineral engineering. The candidacy examination for the doctorate is entirely written, with the exception that the oral examination for the M.S. degree at The Pennsylvania State University may be used as the candidacy examination for the doctorate. If this is done, the M.S. examination will be more detailed and broader in scope than it would be for the M.S. alone. The comprehensive examination for the doctorate includes written examinations in the major program and minor fields in addition to the oral examination required by the Graduate School. The communication and foreign language requirement for the Ph.D. degree may be satisfied by competence (as defined by departmental rules) in one foreign language or mathematical statistics.

Students with deficiencies of 9 credits or fewer in either program may be admitted as degree candidates but will be required to make up such deficiencies without these credits being applicable toward the advanced degree. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p.230).

MINERAL ECONOMICS (MN EC)

453. Nonmetallic Minerals (3)
483. Economics of the Metals Industries (3)
484. Political Economy of Energy and the Environment (3)
486. The Energy Market (3)
490. Mineral Valuation (3)
491. Analysis of Mineral Data (3)
496. Mineral Industries Decision Making (3)

500. Advanced Readings in Mineral Economics (3) Selected readings on topics in mineral history, mineral economics research, applications of economic theory, mineral policy and law, and mineral exploration.

504. Advanced Principles of Mineral Economics (3) Minerals as capital — taxation, conservation, and land tenure; operations of mineral markets; government policy; minerals in world trade and development.

506. Advanced Studies in Mineral Commodities (3) Economic studies of selected mineral commodities and their products. Prerequisite: Mn.Ec. 491.

509. (Geol. 509) Geology and Economics of the Construction Materials (3) Occurrence, origin, and marketing of the mineral materials used by the construction industry. Economic and geologic evaluation of actual deposits.

510. (Geol. 510) Geology and Economics of the Industrial Materials (3) Occurrence, origin, and marketing of the industrial minerals and evaluation of deposits. Chemical and ceramic raw materials emphasized.

513. Appraisal of Mineral Resources and Analysis of Exploration Decisions (3) Mineral resource concepts; various quantitative methods for resource evaluation, including computer simulation; exploration economics and decision making within quantitative frameworks. Prerequisites: Mn.Ec. 490, 491.

590. Colloquium (1-3)

593. Technical Problems in Mineral Economics (1-12) Individual research involving library, laboratory, or field work designed to provide solutions to a selected technoeconomic problem in mineral industries. Prerequisites: Mn.Ec. 500, 504.

MINERAL ENGINEERING MANAGEMENT (M E M)

R. V. Ramani, *Acting Section Chairman of Mineral Engineering Management*
118 Mineral Industries Building

Degree Conferred: M.Eng.

Graduate Faculty: Senior Members Aplan, Essenhigh, Falkie, Farouq Ali, Given, Griffiths, Healy, Hummel, Lovell, W. Miller, Niebel, Ridge, Rosenshine, Schenck, Slobod, Stahl, Stefanko, and Williamson.

Graduate Faculty: Associate Members Guild, Manula, Morley, Saperstein, and Slater.

This program is designed to educate engineers for advancement into executive production management positions in the mineral and heavy construction industries, in development and sales in manufacturing companies, and in consulting firms. Its aim is to provide the knowledge, skills, and attitudes needed by persons to become innovators and responsible decision-making

leaders. Participants are trained to create new designs, systems, and methods, and to plan, develop, and lead mineral industry organizations.

The content of appropriate courses is based upon specific problems encountered in the mineral industries. Such courses are offered by the departments which have combined their resources to offer this interdisciplinary effort: the Departments of Mineral Engineering (Mining and Petroleum and Natural Gas sections), Mineral Economics, Material Sciences, and Industrial and Management Systems Engineering. Courses in these areas and others may be selected by students and adapted to their individual interests.

The program emphasizes quantitative methods, principles of economics applied in mineral industries, and management.

Students are required to present a scholarly written report on a suitable project, the topic of which may be suggested by industry.

For admission a bachelor's degree in one of six engineering branches of mineral industry (mining, petroleum, mineral processing, metallurgy, fuel, and ceramics) or some other closely related field (industrial, civil, geological, mechanical, or chemical engineering) is required. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exception to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

MINERAL ENGINEERING MANAGEMENT (M E M)

510. PRODUCTION AND OPERATIONS MANAGEMENT (3-9) Overall planning, design, and selection of equipment; programming and scheduling of mineral operations; statistical control of costs and production indices.

MINERAL PROCESSING (MN PR)

FRANK F. APLAN, *In Charge of Graduate Programs in Mineral Processing*
4 Mineral Sciences Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Aplan, Austin, and Sun.

Graduate Faculty: Associate Member Hogg.

This program is one of the options in which a graduate student in the Department of Material Sciences can receive an advanced degree. After ores and minerals are mined, they are usually processed to concentrate valuable components or remove undesirable components; then they are converted into useful products. The process engineering involves large plants which treat millions of tons of material per year at low cost, and is essential to such important industries as coal, power generation, steel, nonferrous metals, heavy chemicals, cement, and nonmetallic minerals. The world is facing shortages of energy, water, and raw materials, and the mineral processing engineering profession will play a key role in reducing and solving these problems. Increased efficiency and new ideas are urgently needed.

The training of a mineral processing engineer involves interdisciplinary combinations of chemistry, physics, the geological sciences, and engineering. This knowledge is then integrated with specialized knowledge — the creation, characterization, separation, agglomeration, and handling of mineral particles; the flotation and surface chemistry of mineral particles; and chemical extractions and separations — to provide the basis for developing and understanding the practical means of removal of valuable material from the rock body.

Pollution control is an important aspect of mineral processing because of the problems of disposal of large quantities of waste produced by the mining, metallurgical, cement, power, and heavy chemical industries, and the volume of process water used by these industries. Many air and water pollution control methods use equipment and processes originally developed for

minerals treatment. Mineral processing methods are involved in the recycling and reuse of metals and other materials. A student may emphasize pollution control in his course work and thesis research. The section also cooperates in the all-University interdisciplinary program leading to the Master of Science in Environmental Pollution Control or the Master of Environmental Pollution Control.

The program of study for each student is decided by a study panel consisting of three faculty members and the student. The communication and foreign language requirement for the Ph.D. degree may be satisfied by reading proficiency in one foreign language. Students whose first language is English must demonstrate proficiency in German, Russian, or Japanese (or other language in which a major body of relevant technical literature exists). Students whose first language is not English will be required to show fluency in reading, speaking, comprehending, and writing English and may in some cases be required to demonstrate proficiency in one other approved language.

Graduates with bachelor's degrees in engineering, chemistry, chemical engineering, materials (ceramics, metallurgy), fuels, geological sciences, mathematics, mining, or physics are eligible for admission. Students with deficiencies may be required to make them up concurrently with their graduate studies. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds (such as industrial experience), abilities, and interests.

The following courses listed elsewhere are appropriate for Mineral Processing students: Mat.Sc. 411, 420; Metal. 401, 402, 404, 420, 421, 423, 424, 425, 460.

MINERAL PROCESSING (MN PR)

*400. Special Problems (1-9)

501. Interfacial Phenomena in Mineral Systems (3) Applications of surface phenomena to mineral engineering systems. Thermodynamics of surfaces, flotation, adsorption of detergents, electrical double layer, flocculation, dispersion. Prerequisite: Chem. 451.

502. Froth Flotation and Agglomeration (3) Intensive study of theory and applications of froth flotation and agglomeration. Prerequisite: Mn.Pr. 501.

505. Physical Separations in Mineral Processing (3) Intensive study of theory and applications of gravity, magnetic, electrostatic, centrifugal and other methods of mineral processing. Prerequisite: Metal. 420.

506. Mineral Process Plant Design (3-10) Process design and economy. Development and quantification of flow sheets. Integration of unit operations. Plant layout, equipment selection and instrumentation. Prerequisite: Metal. 420.

507. Chemical Methods in Mineral Processing (3) Practice and theory of methods to upgrade ores by chemical treatment including roasting, solubility separations, surface phenomena, and reactions. Prerequisite: Metal. 420.

508. Mineral Particle Systems (3) Creation, characterization, separation and agglomeration of particles. Comminution, sizing, fractionation of powders; surface area, pore size determinations. Agglomeration and balling.

509. Particle-Fluid Dynamics (3) Movement of particles in fluids, rheology of non-Newtonian mineral suspensions, design of concentrating devices, fluidized beds, electrodynamic, magnetic separations.

590. Colloquium (1-3)

596. Individual Studies (1-6)

597. Special Topics (1-6)

MINERALOGY AND PETROLOGY (MIN P)

ARTHUR L. BOETTCHER, *In Charge of Graduate Programs in Mineralogy and Petrology*
211 Deike Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Barnes, Bates, Boettcher, Burnham, Dachille, Deines, Griffiths, Keith, Langmuir, Muan, Newnham, Rose, Roy, Smith, Thornton, W. White, and Wickman.

Graduate Faculty: Associate Members Kerrick, Ohmoto, and Suhr.

Areas of specialization include igneous, sedimentary, and metamorphic petrology, experimental petrology, mineralogy, crystallography, crystal chemistry, X-ray mineralogy, clay mineralogy, ore mineralogy, and application of statistics in the earth sciences.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages or by comprehensive knowledge of one.

The general requirements for admission are mathematics through integral calculus; chemistry through quantitative analysis; 10 credits in general physics; and 30 credits in geology, petrology, and mineralogy including microscopical petrography. Additional specific requirements must be fulfilled in most areas of specialization.

Students who have taken somewhat less than the indicated minimum of subjects may be admitted but must make up their deficiencies concurrently with their graduate studies. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

The nonthesis option is available for the M.S. degree.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 230).

MINERALOGY (MIN)

400. (Cer.Sc. 400) NONMETALLIC CRYSTAL CHEMISTRY (2-3)

402. MINERALOGY AND PETROLOGY FOR TEACHERS (3) *Mr. Thornton*

411. (Mat.Sc. 411) INSTRUMENTAL TECHNIQUES APPLIED TO MATERIALS AND MINERAL SCIENCE PROBLEMS (1-6)

Unit A. X-RAY DIFFRACTION

Unit B. TRANSMISSION ELECTRON MICROSCOPY *Mr. Thrower*

Unit C. SPECTROSCOPY *Mr. Suhr*

Unit D. ELECTRON MICROPROBE ANALYSIS *Mr. E. White*

Unit E. SCANNING ELECTRON MICROSCOPY *Mr. E. White*

Unit F. ABSORPTION SPECTROSCOPY

421. (Mat.Sc. 421) X-RAY DIFFRACTION (3) *Mr. Smith*

450. VOLCANOLOGY (3) *Mr. Thornton*

463. OPTICAL MINERALOGY (3) *Mr. Kerrick*

483. PETROLOGY (3) *Messrs. Kerrick and Thornton*

484. PETROLOGY AND GEOCHEMISTRY OF SEDIMENTS (3) *Messrs. Griffiths and Langmuir*

490. PETROGRAPHIC PROBLEMS (1) *Mr. Thornton*

500. OPTICAL CRYSTALLOGRAPHY OF MATERIALS (3) Optical methods, microscopic techniques, and measurement of optical constants of crystals; theory and application of the universal stage. Prerequisite: Min. 463. *Mr. Kerrick*

*510. METAMORPHIC PETROLOGY (2-6) Detailed review of chemical, mineralogical, and structural changes that take place during metamorphism. Prerequisite: Min. 483, 484. *Mr. Kerrick*

*Credits to be arranged, 2-4 per term.

513. Scientific Method in Geoscience (3) Problem formulation, sampling designs, selection of variates, and comparison of techniques for analysis of aggregates. *Mr. Griffiths*

514. Statistical and Electronic Data Processing Procedures for Geoscience (3) Statistical analysis of experimental data using univariate and bivariate procedures. *Mr. Griffiths*

515. Ore Microscopy (3) Optical and hardness measurements and phase equilibria as used in identification and interpretation of textures of ore minerals. *Mr. Barnes*

525. Igneous Petrology (2-6) Origin, distribution, and composition of igneous rocks. Prerequisites: Gchem. 513; Min. 483, 484, 500, 527. *Messrs. Burnham and Thornton*

526. Problem Solving in Geoscience (3) Multivariate statistical analysis, decision making, operations research, and systems analysis in geoscience. *Mr. Griffiths*

527. Mineralogy I — Silicates (3) Detailed study of the crystal structures and crystal chemistry of the silicate minerals. *Mr. Smith*

528. Mineralogy II — Nonsilicates (3) Detailed study of the crystal structures and crystal chemistry of the nonsilicate minerals. *Mr. Smith*

530. (Cer.Sc. 530) Structure, Properties, and Occurrence of Clay Minerals (2-5) Structure analysis and identification of clay minerals; mineral transformations and behavior; occurrence, genesis, and petrography of fine-grained sediments.

531. (Mat.Sc. 531) Transmission Electron Microscopy (2) Discussion of electron image contrast theory as a tool for study of atomic substructures in the materials and mineral sciences. Prerequisite: Min. 411B (Mat.Sc. 411B). *Mr. Thrower*

532. (Mat.Sc. 523) Structure Analysis (2) Crystal structure determination methods: space groups, structure factors, heavy atoms and isomorphous replacement, Fourier synthesis, Patterson maps, inequalities, refinement techniques. Prerequisite: Mat.Sc. (Min.) 421. *Messrs. Newnham and Smith*

533. (Mat.Sc. 533) Single Crystal Methods (2) Experimental techniques in crystal structure determination: crystal selection, space group determination, measurement of intensities, analysis of data. Prerequisite: Mat.Sc. 421 or Min. 421. *Mr. Ryba*

534. (Mat.Sc. 534) Diffraction by Crystals (2) Interaction of radiation with matter: coherent and incoherent scattering, extinction, fluorescence, polarization. Prerequisite: Min. (Mat.Sc.) 421. *Mr. McKinstry*

535. (Mat.Sc. 535) Geometrical Crystallography (3) Derivation of lattices, types, point groups and space groups with applications. *Mr. Smith*

538. (Mat.Sc. 538) Electron Beam Analysis of Solids via X-Ray and Electron Emission (3) Theory of phenomena occurring in electron-bombarded solids and their applications to analysis of solids. *Mr. E. White*

540. Meteoritics (2) Mineralogy, petrology, and chemistry of meteorites; theories of their origin and formation. Prerequisite: Min. 483 or 501. *Mr. Wickman*

590. Colloquium (1-3)

596. Individual Studies (1-6)

597. Special Topics (1-6)

Note: *Additional general courses in this field are listed under Geological Sciences.*

MINING ENGINEERING (MNG E)

LEE SAPERSTEIN, *Acting Section Chairman of Mining Engineering*
118 Mineral Industries Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Falkie, Hardy, Lovell, Stefanko, and Voight.

Graduate Faculty: Associate Members Manula, Morley, Ramani, and Saperstein.

Areas of specialization which may be followed in research and course work include mine property valuation and economics of mining engineering (ore estimation, cost analysis and control, budgeting); mechanization and mine plant (unit operations, materials handling, continuous mining, power supply); development and exploitation methods (mine planning and layout, design of systems); mine management, production engineering (work and methods analysis, operations analysis); operations research, environmental control and health and safety (gas and dust technology, ventilation, air conditioning, hygiene, illumination, noise, safety, mine drainage, land reclamation, waste disposal); and rock mechanics (stress analysis, roof and ground control, penetration, fragmentation, subsidence).

Students who desire to obtain the Master of Engineering degree in mining engineering must take a minimum of 30 credits (including at least 12 credits at the 500 level) of appropriate courses in the major area and elective courses. A scholarly written report is also required. Programs of study are available in general mining engineering, rock mechanics, mine operations, research systems engineering, internal or external mine environmental control, mine health and safety; and emphasis can be given to any of the areas listed above.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by completion of courses in two languages or by completion of courses in one language and 6 credits of computer science. A thesis is required for the M.S. degree.

A bachelor's degree in mining engineering or a related engineering field is required for admission. Students may be required to make up deficiencies in their area of specialization. Certain basic related courses outside the department may be approved as part of the major. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 230).

MINING (MNG)

400. MINING AND OUR ENVIRONMENT (3)
402. MINE PLANT DESIGN (3)
410. MINING ENGINEERING ANALYSIS (3)
411. MINE SYSTEMS ENGINEERING (3)
422. MINE VENTILATION AND AIR CONDITIONING (3)
431. ROCK MECHANICS (3)
451. ADVANCED MINING ENGINEERING (1-3)

513. MINE COST ANALYSIS (3) Nature of mining costs, their analysis and control: depreciation and depletion, capital and operating costs, budgets, records.

514. MINE OPERATIONS ANALYSIS (3) Application of operations research techniques in determining optimal design and operating policies for mine management. Prerequisite: Mng. 411.

515. MINE SYSTEMS SIMULATION (3) Principles and practices of probabilistic and deterministic simulation in the analysis of operating systems related to mills and mines. Prerequisites: Cmp.Sc. 401, Mng. 411.

531. Rheological and Strength Characteristics of Rocks (3) Properties of rocks and their determination; failure theories; brittle to ductile transition; rheological behavior. Prerequisite: Mng. 431.

532. Special Topics in Rock Mechanics (1-3) Behavior of rock under static loading; underground stress instrumentation; experimental stress analysis; design of mine openings; theories of subsidence.

542. Theory of Rock Fragmentation (3) Behavior of rock under dynamic loads intended to fragment; physical chemistry of explosives; detonation; theory of blasting; design of drill rounds. Prerequisites: E.Mch. 13, Mng. 30, Psy. 203.

543. Strata Control Engineering (3) Theoretical considerations; convergence, abutments, subsidence; rockbursts; underground support systems; design of mine openings. Prerequisite: Mng. 431.

545. Rock Mechanics Instrumentation (3) Strain gage circuitry, transducers, electrohydraulic servo installations, and integrated strain and force measuring systems as applied to rock mechanics. Prerequisite: Mng. 431.

580. Mining Engineering Research (1-3 per term) Supervised research on a specific problem involved in mining science or technology.

590. Colloquium (1-3)

MUSIC (MUSIC)

Robert W. Baisley, *Head of the Department*
232 Music Building

Degrees Conferred: M.A., M.F.A.

Graduate Faculty: Senior Members Baisley and Brinsmaid.

Graduate Faculty: Associate Members Brown, J. Feldman, L. Feldman, Fenner, D. Miller, P. J. Miller, and Perison.

The Master of Arts degree program offers opportunities for concentration in two areas, music history and music theory. Admission to the program requires a recognized music major or its equivalent, and a reading knowledge of one foreign language. A thesis is required of all M.A. candidates. While 30 credits are listed as a minimum requirement, it should be noted that the amount of course work necessary may exceed the minimum, according to the needs and background of the student involved.

The Master of Fine Arts degree program is planned to provide professional emphasis. Students will specialize in either performance or composition. In addition to credit requirements, admission to the program is contingent upon department certification of the candidate's competence. According to the area of specialization, an audition or submission of manuscripts is required. Arrangements for this can be made by the student with the department. While 48 credits are listed as a minimum requirement, it should be noted that the amount of course work necessary may exceed the minimum according to the needs and background of the student involved.

Students who lack the recommended upper-class courses in music may be required to take additional course work without receiving graduate credit.

The department sponsors musical activities, and candidates for both degrees are required to participate in positions of responsibility.

Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests.

MUSIC (MUSIC)

410. Music of the Twentieth Century (3)
412. Music of the Baroque Period (3)
413. Music of the Middle Ages (3)
414. Music of the Renaissance (3)
417. Music of the Classical Period (3)
418. Music of the Romantic Period (3)
*429. Vocal Style (3) Fee $80.
455. Form and Analysis (2)
457. Composition (2)
459. Orchestration and Arranging (3)
465. Form and Analysis (2)
466. Advanced Conducting (2)
467. Opera Workshop (1-6)
468. Advanced Chamber Music (1-6)

*501. Advanced Harpsichord (3) Instruction in harpsichord playing; preparation for recital performance. Fee $100.

*503. Advanced Orchestral Instruments (3) Study, repertoire building, and recital performance. Fee $80.

*511. Advanced Piano (3) Piano literature of all periods for public performance. Fee $80.

*520. Voice (3) Study, repertoire building, and recital performance. Fee $80.

*531. Advanced Organ (3) Study, repertoire building, and recital performance. Prerequisite: 4 credits of Music 31 and/or 38. Fee $100.

543. Modern Harmony (3) Harmonic writing based on twentieth-century practices with attention to traditional idioms that serve as foundation.

545. Counterpoint (3) Principals of contrapuntal techniques from the sixteenth century to the present. Required of all M.F.A. candidates in composition.

*558. Free Composition (3) Composition: vocal and instrumental, standard or modern idioms.

**560. Orchestral and Choral Conducting (3) Supervised conducting in selected performance situations, rehearsal techniques and comprehensive score analysis.

571. Performance Practices (3) Analysis and performance of music of various periods based on manuscripts, documents, and other source materials.

580. Studies in Orchestral Literature (3) Selected studies in orchestral literature from the seventeenth century to the present.

581. Studies in Chamber Music Literature (3) Selected studies in chamber music of all types from the seventeenth century to the present.

582. Studies in Keyboard Literature (3) The literature of major keyboard instruments from the sixteenth century to the present.

583. Studies in Choral Literature (3) Selected studies in choral literature of all types from the Renaissance to the present.

584. Studies in Operatic Literature (3) Studies in the development of the opera from 1600 to the present, treating both libretto and music.

589. Music Seminar (1-6) Seminar in the history, art, and science of music, with readings, discussion, and performance.

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*Course may be scheduled only by conference with the head of the department. May be repeated for a total of 18 credits.
**May be repeated for total of 9 credits.

MUSIC EDUCATION (MU ED)

WARREN E. GEORGE, *Head of the Department*
264 Chambers Building

Degrees Conferred: D.Ed., M.Ed.

Graduate Faculty: Senior Members Boyle, Deihl, Dunlop, and George.

Graduate Faculty: Associate Member Schmalstieg.

Graduate programs in music education prepare students for careers in public school music teaching, music supervision, college teaching, administration, or research. It is possible to include study in a number of these areas in the M.Ed. or D.Ed. programs.

Completion of a recognized music education major, or program leading to teaching certification in music, is a prerequisite for admission to the M.Ed. or D.Ed. programs.

Applicants for the master's program who present a 2.50 junior-senior average and two satisfactory professional references will be considered for admission to the Department of Music Education, provided they have appropriate course backgrounds and musical proficiency.

Admission to the doctoral program requires: a junior-senior minimum average of "B"; approximately half of any graduate credits of "A" quality; interview prior to admission; submission of satisfactory score on Miller Analogies Test; five recommendations attesting to scholarship, musicianship, and ability to do independent study; and a minimum of two years of successful teaching experience in public or private schools.

The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum grade-point average may be made for students with special backgrounds, abilities, and interests.

MUSIC EDUCATION (MU ED)

415. Workshop in Selected Music Education Studies (1-6)
445. Methods, Elementary Grades (3)
446. The Elementary Music Specialist (3)
448. Methods, Junior and Senior High Schools (3)
449. Student Teaching in the Elementary School (2-6)
450. Student Teaching in the High School (2-6)
454. Orchestra and Band Methods and Materials (3)
455. Student Teaching in Instrumental Music (2-6)
468. The Teaching of Piano (3)
469. Band and Orchestra Technique (3)
471. Teaching Marching Band (3)
472. Wind Instrument Materials (3)
473. Psychological Foundations of Musical Behavior (3)
474. Tests and Measurements in Music (3)
480. Choral Program in the Secondary School (3)
487. Children's Songs and Records (3)

500. Music Education Seminar (3-6) Problems of various phases of music education, both instrumental and vocal; research and literature dealing with these problems.

501. Problems and Projects in Music Education (1-6) Independent work on special topics of music education pertinent to the development of curricula, methods, and materials in music education. Prerequisite: 12 graduate credits in education (including music education).

525. Proseminar: Graduate Study in Music Education (1-3) Bibliography; location and evaluation of reference materials; organization, form, style in preparing music education research reports and other papers.

555. Research Methods in Music Education (3-6) Research methods and designs for problems in music education; techniques for studying cognitive, affective, and psychomotor

responses to musical stimuli. Prerequisites: Mus.Ed. 525; Ed.Psy. 475; Ed.Psy. 406 or 407.

569. Present-Day Trends in Instrumental Music (3-6) New methods and materials for band, orchestra, and ensembles.

570. Choral Technique (3-6) Analysis and evaluation of choral materials appropriate for secondary school chorus; program building; practical rehearsal and conducting techniques. Prerequisite: 6 credits of vocal study.

572. Instrumental Pedagogy (3-6) Research problems in band and orchestra. Prerequisite: Mu.Ed. 54 or practical experience.

573. The Materials of Appreciation (3) Examination of written and recorded materials and appropriate techniques for developing appreciation of music, grades one through twelve.

574. Present-Day Trends in Music Education (3-6) Present-day music education materials and methods (elementary and secondary levels) in relation to modern educational philosophy; emphasis on practical problems presented by members of the class. Prerequisites: Mu.Ed. 48, teaching experience.

575. The Junior High School Music Curriculum (3) Instructional materials, procedures, curricular and extracurricular activities, integration with other subjects.

576. Music Supervision (3) Current educational procedures in training music supervisors.

581. Contemporary Music Education (3) Prerequisite: 20 credits at the graduate level including Mu.Ed. 500.

582. Theory and Projects in Musical Learning (3-6) Experimentation and self-instructional techniques involved in musical learning projects. Prerequisite: Inst.M. 435.

591. Internship in Music Performance Techniques (1-6) Internship in selected school or music performance situations other than those in the district where the graduate student is employed.

594. Pedagogy of Music Theory, Reading, and Ear Training (3) Instructional theory and materials basic to teaching music theory, reading, and ear training. Musical instruments, audio-visual devices as aids. Prerequisite: 12 credits in music theory and/or harmony.

NUCLEAR ENGINEERING (NUC E)

Warren F. Witzig, *Head of the Department*
231 Sackett Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members Diethorn, Foderaro, Jacobs, Kenney, Klevans, Levine, Palladino, Remick, Schultz, and Witzig.

Graduate Faculty: Associate Members Jester and Robinson.

Programs of study are individually tailored, and engineering is emphasized through the study of reactor principles — computational methods, transport theory, and nuclear design; plasma principles — waves, analysis, and fusion laboratory; shielding — Monte Carlo methods and two-body kinematics; reactor systems design — thermal, mechanical, and control; reactor fuels — configuration, radiation effects, and fuel cycle management; isotope utilization — activation analysis, chemical processes including copolymerization and nuclear medicine; plowshare applications; safety analysis — reactor siting, engineered safeguards, and environmental effects. The department offers three degrees at the master's level: M.Eng., M.S. with paper, and M.S. with thesis. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language and proficiency in English.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of

spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

NUCLEAR ENGINEERING (NUC E)

400. Nuclear Engineering Special Topics (1-12)
401. Introduction to Nuclear Engineering (3)
402. Introductory Reactor Analysis II (3)
410-411. Nuclear Reactor Theory (3 each)
415. Radionuclear Applications (3)
420. Radiological Safety (3)
425. (Bio.E. 425) Radiographic Imaging (3)
428. Radioactive Waste Control (3)
430. Design Principles of Reactor Systems (3)
431. Synthesis of Nuclear Systems (3)
440-441. Nuclear Engineering Laboratory (3 each)
490. (E.E. 490) Introduction to Plasmas (3)

501. Reactor Engineering (3) Reactor controls, shielding of nuclear reactors, stress analysis of reactor materials, power cycle analysis, breeding, and advanced design considerations. Prerequisite or concurrent: Nuc.E. 411.

502. Reactor Engineering Laboratory (1-5) Reactor experiments devised to acquaint the student with reactor technology. Prerequisite or concurrent: Nuc.E. 411.

503. Thermonuclear Engineering (3) Binary fusion reactions; microscopic and macroscopic phenomena in a completely ionized gas; electromagnetic confinement; design, operation, and diagnostics of experiments. Prerequisite: Math. 452.

505. Reactor Instrumentation and Control (3) Neutron-detecting instruments and circuits; in-core power instrumentation; reactor control principles; control mechanisms; operational control problems. Prerequisite: Nuc.E. 411.

506. Two-Body Kinematics (3) Conservation laws of classical and quantum mechanics and their application to interactions between two bodies. Prerequisite: Math. 72.

507. Interaction of Radiations with Matter (3) Theory of the processes by which gamma rays, neutrons, and charged particles interact with electrons, atoms, and nuclei. Prerequisite: Nuc.E. 506.

509. Radiation Damage in Solids (2) Production of defects by high energy particles; nature of defects; diffusion and annealing in solids; macro property changes. Prerequisite: Nuc.E. 507.

511. Nuclear Reactor Materials (3) Philosophy, selection, technology, use, economics, and performance of materials of major interest in nuclear power reactors today. Prerequisite: Nuc.E. 411.

520. Reactor Analysis (3) Physical principles and mathematical methods of reactor analysis. Prerequisite: Nuc.E. 410.

521-522. Neutron Transport Theory (3 each) Derivation of Boltzmann equation for neutron transport; techniques of approximate and exact solution for the monoenergetic and spectrum regenerating cases. Prerequisite: Nuc.E. 410 or Phys. 406.

540. (E.E. 540) Theory of Plasma Waves (3) Solutions of the Boltzmann equation; waves in bounded and unbounded plasmas; radiation and scattering from plasmas. Prerequisite: Nuc.E. 490.

541. (E.E. 541) Plasma Theory (3) Advanced topics in kinetic theory, fluctuation theory, microinstability, and turbulence. Prerequisite: Nuc.E. 540 (E.E. 540).

590. Colloquium (1-3)

596. Individual Studies (1-6)

597. Special Topics (1-6)

NURSING (NURS)

LAURIE M. GUNTER, *Head of the Department*
15 Henderson Human Development Building

Degrees Conferred: M.N., M.S.

Graduate Faculty: Senior Members Brantl and Gunter.

Graduate Faculty: Associate Members Ashley, Baltes, Pierce, Porter, Quiring, Sedgwick, and Williamson.

The department recognizes the need for two types of advanced degrees in nursing — academic and professional. The Master of Science degree is offered in recognition of the completion of programs which emphasize productive scholarship and research and preparation for teaching or administration. The Master of Nursing degree is offered in recognition of the completion of programs which emphasize the practical application of science to the solution of nursing and health care problems and preparation as a specialized nurse clinician.

The student may select one of the following emphases in nursing: (1) health care, (2) acute or intensive care nursing, (3) long-term care. Options within these emphases for clinical specialization in health nursing are offered in family health, community mental health, adult health and aging, and transcultural nursing.

For the Master of Science degree, each student must have a minimum of 40 graduate credits with at least 30 earned as approved residence credits. Included in these requirements are a minimum of 3 credits in nursing practicum, 6 credits to support the career goal of administration or teaching, and 10 credits in thesis and methods of research. Each student is required to complete a thesis and successfully pass a comprehensive examination.

For the Master of Nursing degree, a minimum of 30 graduate credits is required with at least 20 to be earned as approved residence credits. At least 10 of these credits must be earned in nursing practicum courses. Each student must present an acceptable clinical paper and successfully pass a comprehensive examination.

Applicants should hold a baccalaureate degree in nursing from an NLN-accredited program or its equivalent. (Students with degrees from non-NLN-accredited programs will be evaluated by the Admissions Committee in the department on an individual basis.) Students judged to have deficiencies may be eligible for admission with the understanding that all deficiencies must be completed. An overall grade-point average of 2.50 on a 4-point scale is expected for undergraduate work.

NURSING (NURS)

405. OCCUPATIONAL HEALTH NURSING (3)
410. NURSING CARE OF THE FAMILY IN THE COMMUNITY (3)
425. SCHOOL HEALTH NURSING (3)
445. TRAUMA NURSING (3)
450. REHABILITATION NURSING (3)
455. ADVANCED MEDICAL NURSING (3)
460. ADVANCED SURGICAL NURSING (3)
490a,b,c,d,e,f,g. NURSING STUDY IN SPECIALIZED SETTING (1-12)

501. ISSUES IN NURSING AND HEALTH CARE (2) Consideration of personal, social, political, economic, philosophical, ethical problems/questions and ways of confronting, and resolving conflicts in professional practice.

522. MEDICATION MANAGEMENT (3) Therapeutic health maintenance principles based upon clinical pharmacology; drug therapy, management; drug metabolism, interaction, side effects,

toxic effects, patient teaching. Prerequisite: basic background in principles of pharmacology.

530. Clinical Process in Health Care and Nursing (3-10) Supervised experience to develop competence in selected clinical or functional areas of health care or nursing practice. Prerequisite: completion of advanced nursing theory courses in selected clinical or functional areas, or permission of instructor.

590. Colloquium (1-3)

596. Individual Studies (1-6)

597. Special Topics (1-6)

NUTRITION (NUTR)

HELEN A. GUTHRIE, *In Charge of Graduate Programs in Nutrition*
202 Henderson Human Development Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.; M.S. in Nutrition in Public Health

Graduate Faculty: Senior Members Guthrie, Pike, and Underwood.

Graduate Faculty: Associate Members Brinkman, Shannon, Teitelbaum, and Wright.

Graduate programs in nutrition prepare students for careers in college teaching, research, industry, and government. The program in nutrition in public health prepares the student for work in public health agencies and community nutrition.

To satisfy the communication and foreign language requirement for the Ph.D. degree students are expected to demonstrate competence in technical writing (Engl. 418) and spoken English.

For admission to a graduate program in nutrition, a student must have completed at least 6 credits in inorganic and organic chemistry, 3 each in biochemistry, microbiology, and human physiology, 4 in other physical and biological sciences, and 8 in foods and/or nutrition. For admission to the program in nutrition in public health, an additional 12 credits in social sciences are required.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Students with up to 9 credits of deficiency may also be admitted. Any deficiencies must be completed with a grade of B within two terms.

For other graduate courses in nutrition see A.Ntr. 501, Energy Metabolism, and A.Ntr. 503, Micronutrients: Nutrition, Metabolism, and Function. Current topics are presented as announced in Nutr. 597.

NUTRITION (NUTR)

400. Special Problems in Foods and Nutrition (1-3)
420. Experimental Cookery (3)
421. Cultural and Aesthetic Aspects of Food (3)
422. Scientific Principles of Food Preparation (3)
452. Nutritional Aspects of Disease (3)
453. Diet Therapy (2)
454. Laboratory Methods in Nutrition (2)
456. Community Nutrition (3)
457. Principles of Human Nutrition (3)
458. Applied Human Nutrition (2)
459. Advanced Nutrition (3)
490. Foods and Nutrition Seminar (1)

520. Readings in Applied Nutrition (2) Critical review and reports of literature on selected topics in applied nutrition.

521. Topics in Nutrition (1-6) Intensive study of current developments on selected topics in nutrition.

522. Advanced Experimental Foods (3) Experimental methods used in measuring the quality of foods; specific problems in food preparation.

530. Problems in Foods and Nutrition (1-6)

550. Readings in Nutrition (3) Readings and reports of selected topics in nutrition.

551. Seminar in Nutrition (1-6) Selected topics and recent advances in nutrition.

552. Nutrition in Disease (3) Physiological and biochemical problems in metabolic diseases and the nutritional aspects of therapy.

555. Field Work in Nutrition (2-4) Field problems planned to meet the needs of individual students. Hours and problems to be arranged.

556. The Survey Method in Foods and Nutrition (2) Study of survey techniques as a tool in the assay of food adequacy and nutritional status.

557. Interrelationships of Nutrients (2) Interrelationships of nutrients in the metabolic processes; their significance as applied to nutrition.

590. Colloquium (1-3)

596. Individual Studies (1-6)

597. Special Topics (1-6)

OPERATIONS RESEARCH (OR)

Stuart H. Mann, *Chairman, Committee on Operations Research*
S-126 Henderson Human Development Building

Degrees Conferred: Students electing this option through participating graduate programs will earn a degree with a dual title at both the Ph.D. and M.S. levels, i.e., Ph.D. in (graduate program name) and Operations Research, or M.S. in (graduate program name) and Operations Research.

Graduate Faculty: Senior Members Aggarwal, Antle, M. Arnold, L. Austin, Coffman, Falkie, Farouq Ali, Fishburn, Gordon, Gould, Griffiths, Haight, Hallberg, Harkness, Hayman, Heitmann, Hu, J. Lewis, Mann, McMurtry, Raphael, Rigby, Rosenshine, Sauerlender, Shilling, and A. V. Williams.

Graduate Faculty: Associate Members Dinkel, Enscore, Ferrar, Guild, Klimko, Kochenberger, Manula, J. Nelson, Parsons, J. H. Patterson, Pfaffenberger, Ramani, Slater, Strack, Summers, Tilton, and Zindler.

The operations research dual-title degree program option is administered by an Operations Research Committee which is responsible for management of the program. The committee maintains program definition, identifies faculty and courses appropriate to the option, and recommends policy and procedures for its operation to the Dean of the Graduate School. This dual-title degree program is offered as an option through graduate major programs in eight Colleges. The option enables students from diverse graduate programs to attain and be identified with the tools, techniques, and methodology of operations research, while maintaining a close association with areas of application. Operations research is the analysis — usually involving mathematical treatment of a process, problem, or operation — to determine its purpose and effectiveness and to gain maximum efficiency. To pursue a dual-title degree under this program option the student must apply to the Graduate School and register through one of the following graduate major programs: business administration, civil engineering, computer science, economics, educational administration, electrical engineering, forest resources, geography, industrial engineering, man-environment relations, mathematics, mineral economics,

mineralogy and petrology, mining engineering, petroleum and natural gas engineering, and statistics.

For the Ph.D. degree with operations research option, in addition to those prescribed by the graduate major program, prerequisites for acceptance to the program without deficiency include the following or their equivalent: Math. 61, 62, 63, 71, and 72 or 100; Cmp.Sc. 101; and 6 credits in elementary or introductory micro- or macroeconomics. There are no prerequisites for admission to the M.S. program option other than those that may be imposed by the participating graduate major programs.

To qualify for a dual-title degree after admission to the program option, students must satisfy the requirements of the graduate major programs in which they are registered, in addition to the minimum requirements, or their equivalent, in the operations research option.

The minimum requirements for the Ph.D. degree with operations research option are: (1) Mathematics — 9 credits minimum including real analysis (Math. 420) and linear algebra (Math. 441); (2) Statistics — 9 credits minimum with a 6-credit sequence in mathematical statistics (Stat. 409, 410) or in experimental statistics (Stat. 401, 402) and 3 credits in stochastic processes (Stat. 427); (3) Optimization — 12 credits minimum including linear programming I and II, mathematical programming I, and dynamic programming; (4) Processes — 9 credits minimum including inventory models, scheduling models, and waiting line models; (5) Computer Science — 6 credits minimum including numerical methods and digital simulation techniques; and (6) Open Areas (application and/or specialization) — 15 credits minimum.

For the M.S. degree with operations research option, 18 credits are required from the areas of statistical methods, computer science, optimization (survey-level courses acceptable), processes (survey-level courses acceptable), and applications. At least 3 credits must be selected from each area. Particular courses may satisfy both the graduate major program requirements and those in the operations research option. A thesis is required, the supervisor of which must be a member of the Graduate Faculty recommended by the chairman of the program granting the degree and approved by the Operations Research Committee as qualified to supervise thesis work in operations research.

A Ph.D. minor program in operations research is available for doctoral students in graduate programs who find it advantageous to include advanced quantitative methods of systems analysis in their program of study and have been approved to do so by their doctoral committee. To qualify for a minor in operations research, students must satisfy the requirements of their graduate major program and take at least 15 credits from the following areas: statistical methods or mathematical statistics, computer science, optimization, and processes. At least 3 credits must be taken from each of optimization and processes areas as listed below.

The doctoral committee is recommended by the graduate major program granting the degree. The chairman and at least two members of a doctoral committee must be members of the Graduate Faculty and approved by the Operations Research Committee as qualified to supervise doctoral theses in operations research. The Operations Research Committee is responsible for administering an examination in operations research which constitutes a portion of the comprehensive examination administered to the doctoral student in the program option, as well as to the candidate who chooses operations research as a minor field.

Courses of a like nature identified as the core of the program option have been given generic names and descriptions. Each such listing may be satisfied by one of the courses given under it.

OPTIMIZATION AREA

Linear Programming I An introduction to the theory and methodology of linear programming.

I.E. 405
Q.B.A. 451

Linear Programming II A further treatment of the theory and methodology of linear programming with emphasis on special formulations.

I.E. 510

Mathematical Programming I Introduction to optimization theory designed to provide the necessary fundamentals for nonlinear programming and more advanced studies in mathematical programming.
Q.B.A. 452

Mathematical Programming II An in-depth treatment of nonlinear programming and geometric programming with emphasis on both theory and applications.
Q.B.A. 550

Mathematical Programming III A seminar dealing with recent advances in mathematical programming.
Q.B.A. 550

Dynamic Programming Study of the concepts underlying model building and optimization of dynamic systems with applications to engineering, economic, and environmental systems.
Stat. 534 (M.E.R. 534)

PROCESSES AREA

Inventory Models A study of inventory theory, deterministic and probabilistic models, single and multiproduct models in single- and multistage processes.
I.E. 508
Mgmt. 518

Scheduling Models Scheduling models with simultaneous job arrival and probabilistic job arrival, network scheduling and scheduling simulation techniques.
I.E. 507
Mgmt. 516

Waiting Line Models Theory of systems involving stochastic delay and stochastic service.
I.E. 509
Q.B.A. 561
Stat. 528

PETROLEUM AND NATURAL GAS ENGINEERING (PNG E)

C. DREW STAHL, *Section Chairman of Petroleum and Natural Gas Engineering*
25 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Burcik, Farouq Ali, Slobod, and Stahl.

Graduate Faculty: Associate Member Slater.

Areas of specialization include experimental and theoretical studies of water flooding and the newer methods for displacing oil from porous media, methods for calculating reservoir performance, scaled laboratory studies of reservoir phenomena, and drilling and well completion problems.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Students who expect to enter graduate study in this program with a degree in another major should present 6 credits in geology, 15 in engineering science, and credit for mathematics through integral calculus. A limited number of deficiencies may be made up after admission. Certain closely related courses outside the department may be counted as petroleum and natural gas credits toward the degree.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 230).

PETROLEUM AND NATURAL GAS (P N G)

400. Thesis (1-6)
410. Applied Reservoir Engineering (3)
420. Applied Reservoir Analysis (3)
421. Reservoir Engineering (3)
430. Reservoir Modeling (3)
440. Formation Evaluation (3)
450. Drilling Design and Production Engineering (3)
475. Petroleum Engineering Design (3)
480. Production Process Engineering (3)
481. Natural Gas and Gasoline Plants (2)
485. Engineering in Secondary Recovery (3)
493. Engineering Evaluation of Oil and Gas Properties (3)

510. Solution of the Partial Differential Equations of Flow in Porous Media (3) The application of mathematical techniques to solve the partial differential equations of steady and unsteady state flow in porous media. Prerequisite: Math. 405.

511. Numerical Solution of the Partial Differential Equations of Flow in Porous Media (3) Differencing schemes for the partial differential equations of single-phase flow; application to flow of gas and mixing in porous media.

512. Numerical Reservoir Simulation (3-6) Mathematical analysis of complex reservoir behavior and combination drives; numerical methods for the solution of behavior equations; recent developments. Prerequisite: P.N.G. 510.

514. Optimization of Petroleum Recovery Processes (3) Optimum search methods, linear programming, nonlinear programming, dynamic programming, application to waterflooding, depletion drive, steam injection, gas cycling, miscible displacement. Prerequisite: P.N.G. 410.

515. Advanced Oil Recovery Techniques (3) Advanced oil recovery techniques including water-flooding, in-situ combustion, steam injection, hot-water injection, and miscible-phase displacement.

519. Design of Thermal Recovery Projects (3) Suitability of reservoirs for thermal oil recovery; case histories; design of in-situ combustion and steamfloods; thermal stimulation; shale oil recovery. Prerequisite: P.N.G. 515.

520. Phase Relations in Reservoir Engineering (3) Phase relations as applied to condensate and retrograde condensate reservoirs and to other problems in petroleum production.

530. Natural Gas Engineering (1-3) Flow in producing or storage reservoirs; gas well testing; transmission systems; storage cycle; current developments. Prerequisite: P.N.G. 481.

590. Colloquium (1-3)

596. Individual Studies (1-6)

597. Special Topics (1-6)

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in petroleum and natural gas studies are listed under Materials Science.*

PHARMACOLOGY (PHARM)

ELLIOT S. VESELL, *Chairman of the Department*
The Milton S. Hershey Medical Center
Hershey, Pa. 17033

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Connor, Fritz, Greene, Jacob, W. Severs, and Vesell.

Graduate Faculty: Associate Members Berlin, Hayes, Hill, Passananti, A. Severs, Smith, and Valerino.

The graduate studies program in pharmacology is designed to give qualified students a combination of didactic instruction, informal direction, and laboratory experience which will enable them to obtain a firm foundation in the principles, methods, and contributions of pharmacology (defined broadly as the science of the multiple aspects of the interaction of chemical agents with biological systems). With this preparation, graduates of the program should be capable of designing and executing high-quality independent research, and of assuming positions of responsibility within the pharmacologic community.

The department offers studies in the general areas of drug metabolism, endocrine pharmacology, neuropharmacology, cardiovascular-renal pharmacology, and clinical pharmacology. Primary emphasis is placed on the molecular mechanism by which drugs act in the body and by which the body transforms drugs.

A bachelor's degree reflecting a reasonable background in zoology or biology, mathematics, and chemistry is required; reading knowledge of one or two foreign languages is recommended. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Two letters of recommendation are required, along with a curriculum vitae and Graduate Record Examination scores.

This program is offered only at The Milton S. Hershey Medical Center.

PHARMACOLOGY (PHARM)

501. PHARMACOLOGY (3) Lectures, discussions, and laboratory study of the mechanism of drug action in biological systems.

502. PHARMACOLOGY (4) Continuation of Pharm. 501.

504. DRUG METABOLISM (3) Study of chemical transformation of drugs within animal cells and drug-metabolizing enzymes present in liver microsomes performing this function. Prerequisite: Pharm. 501.

506. PHARMACOLOGY OF ENDOCRINE ORGANS (3) Current concepts of interaction of endocrine tissue with endogenous compounds and pharmacological agents. Prerequisite: Pharm. 501.

507. PHARMACOLOGY OF PSYCHOACTIVE DRUGS (3) Current theories of mental diseases and pharmacological agents used to treat them. Prerequisite: Pharm. 501.

508. PHARMACOLOGY OF BIOLOGICALLY ACTIVE MONAMINES (3) The role of monamines in body function in alteration of their activity by drugs. Prerequisite: Pharm. 501.

509. DEVELOPMENT OF THERAPEUTIC AGENTS (3) Stages of drug development ranging from laboratory studies to routine human consumption.

512. CLINICAL PHARMACOLOGY (3) Drug therapy of cardiovascular, renal, and neural diseases.

515. HUMAN GENETICS (2) Seminar-type presentations by students and staff on fundamental problems and current topics in human genetics.

520. PRINCIPLES OF DRUG ACTION (2) Detailed analysis of basic parameters governing drug actions.

525. Pharmacology of Antitumor Drugs (2) Study of the mechanisms of antitumor drug action in biological systems. Prerequisite: Pharm. 501.

530. Pharmacology of Psychotropic Drugs (2) Systematic analysis of the effects of psychotropic drugs.

540. Pharmacogenetics (3) Study of human responses to individual drugs.

550. Neuropharmacology (2) Study of mechanisms of action of drugs which alter neuronal transmission in the peripheral and central nervous systems.

560. Pharmacology Seminar (1-3 per term) Student and staff seminar designed to familiarize medical and graduate students with current research developments in the field.

570. Special Topics (1-6) Introduction of students to the research laboratory and the scholarly pursuits of members of the staff.

571. Techniques in Pharmacological Research (2) Classes will be comprised of lectures by the faculty of the Pharmacology Department, followed by working demonstrations of the techniques.

590. Research (1-12) Individualized research conducted by students in departmental laboratories.

PHILOSOPHY (PHIL)

Carl R. Hausman, *Head of the Department*
247 Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty: Senior Members Anderson, Gotshalk, Hausman, Johnstone, Kockelmans, Lingis, Rosen, and Seebohm.

Graduate Faculty: Associate Members Flay, Ginsberg, Goldman, Kennington, Price, Tsugawa, Vaught, and Verene.

A thorough grounding in the history of philosophy is desirable for all students. Specialization is possible in areas (such as aesthetics, metaphysics, ethics, social philosophy, logic, and history and philosophy of science); in movements of thought (such as rationalism, empiricism, idealism, phenomenology, and existentialism); or in any of the major figures in the history of western philosophy. Specialization is also possible in a joint program with the Department of Mathematics in logic and the foundations of mathematics and with the Department of Physics in philosophy of science. Undergraduate preparation to the extent of a strong minor is advisable. The department may waive the requirement of a thesis for an M.A. candidate.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages or by comprehensive knowledge of one.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

PHILOSOPHY (PHIL)

406. Medieval Philosophy (3)
408. Studies in Social and Political Philosophy (3)
410. Studies in Greek Philosophy (3-6)
411. Studies in Modern Philosophy (3-6)
412. Studies in Contemporary Philosophy (3-6)
413. Philosophy of Literature (3)
414. Aesthetic Theory (3)

417. Studies in Nineteenth-Century Philosophy (3-6)
419. Philosophical Backgrounds of American Thought (3)
420. Philosophy of History (3)
421. Studies in the Philosophy of Science (3)
424. Studies in Philosophy of Religion (3)
426. Metaphysics (3-6)
427. Advanced Ethics (3)
428. (Math. 428) Logical Theory (3)
429. Semantics: Philosophy of Language and Symbolism (3)
430. Philosophical Problems (1-9)
435. (S.T.S. 435) The Interrelation of Science, Philosophy, and Religion (3)

500. Ethics: Historical and Systematic (2-6) Critical study of some phase of ethical theory, or of some period of the history of ethics.

504. Social and Political Philosophy (3-6) Critical study of basic problems in their historical and functional setting.

505. Philosophy of Western Religion (3-6) The consideration of contemporary western religious concepts in terms of their Graeco-Judean traditions.

506. Seminar in Ancient Philosophy (3-6) Study of one or more important men or movements in ancient philosophy.

508. Seminar in Modern Philosophy (3-6) Men and movements in philosophy from the Renaissance through the nineteenth century.

509. Seminar in Contemporary Philosophy (3-6) Men and movements in twentieth-century philosophy.

512. Advanced Topics in Philosophy of Science (3-6) Crucial problems in the theory of science and scientific method.

513. (Psy. 513) Principles and Methods of Empirical Science (3) Scientific methodologies and their presuppositions, with special emphasis on behavioral and social sciences.

514. Seminar in Nineteenth-Century Philosophy (3-6) Study of a philosopher or philosophical movement of the nineteenth century.

515. Philosophical Method (3-6) Methods proposed by classical and contemporary thinkers for reaching philosophical conclusions: deductive, inductive, dialectical, pragmatic, intuitive.

516. Seminar in Aesthetics (3-6) Problems and theories in the nature of art.

526. Seminar in Metaphysics (3-6) Formulation and analysis of metaphysical problems in the various fields of philosophy.

530. Philosophy Research Seminar (1-12) Study of selected philosophical problems with an emphasis on techniques of philosophical research.

550. (Math. 550) Foundations of Mathematical Logic (3) The nature of logical basis of mathematics; critical examination and development of the basic parts of logical calculus. Prerequisite: Math. 480 or Phil. 428.

554. (Math. 554) Logic and Metamathematics I (3) Completeness, Löwenheim-Skolem, Herbrand, and compactness theorems; first-order theories; categoricity, elimination of descriptions, decidability; algebraic and geometric applications. Prerequisite: Phil. 428.

557. (Math. 557) Logic and Metamathematics II (3) Arithmetization; Gödel and Tarski incompleteness theorems; undecidability results; Gentzen-type systems and consistency results. Prerequisite: Phil. 428.

590. Colloquium (1-3)

597. Special Topics (1-6)

PHYSICAL EDUCATION (PH ED)

KARL G. STOEDEFALKE, *Associate Dean for Graduate Study and Research*
275 Recreation Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Buskirk, Gross, Harris, Hunt, Kollias, Lucas, Mendez, Morehouse, Nelson, Rhoades, Stoedefalke, and van der Smissen.

Graduate Faculty: Associate Members Cavanagh, Christina, Clarke, Gahagen, Hodgson, Lundegren, Magnusson, Nicholas, Smith, and Thompson.

The master's degree program is designed to prepare students to be better teachers in the elementary and secondary schools, in community colleges, and in the service and lower division professional programs of senior colleges and universities, while the doctoral program is directed toward careers in research and in teaching at the advanced undergraduate and graduate levels in colleges and universities. The graduate programs are directed toward involvement of the student in gaining greater depth of understanding regarding the foundations of physical education. All degrees require experience with research to enable the student to better analyze problems, assess information, draw logical conclusions, and apply research findings.

Areas of specialization include (1) adapted physical education, (2) administration-supervision, (3) biomechanics (applied anatomy and kinesiology), (4) exercise specialist, (5) health education, (6) history of sport and physical education, (7) motor learning, (8) performance assessment, (9) physiology of exercise (physical conditioning, physical fitness, and performance stress), (10) psychosocial foundations of physical activity, and (11) recreation and parks.

Admission to the master's program requires a major in physical education or its equivalent in comparable course work. Especially desirable is a concentration on the physical, biological, behavioral, or social sciences, depending upon the intended areas of specialization.

Admission to doctoral study requires the master's degree or its equivalent, demonstrated research ability in the form of a thesis or published research, and acceptable performance on the Aptitude Test of the Graduate Record Examination. A student who has earned a master's degree in recreation and parks and meets the above requirements may enter a doctoral program in physical education with specialization in recreation and parks. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

See also Recreation and Parks.

HEALTH EDUCATION (HL ED)

405. PREVENTION AND CARE OF ATHLETIC INJURIES (3)
411. PRINCIPLES AND METHODS OF TEACHING SAFETY EDUCATION (3)
456. ADVANCED TECHNIQUES IN SCHOOL COMMUNITY HEALTH EDUCATION (3)
496. SPECIAL PROJECTS (1-6)

511. (Anthy. 511) HEALTH IMPLICATIONS IN THE GROWTH AND DEVELOPMENT OF SCHOOL CHILDREN (3) Child growth and development emphasis for teachers; medical inspection and examination; preschool program; early habit formations; behavior problems; cooperation of parents, teachers, and children. Prerequisite: Hl.Ed. 215.

513. (Anthy. 513) HEALTH IMPLICATIONS IN MATURITY AND AGING (3) Changes in the human body in maturity and aging. Theories and mechanisms of physiologic aging with implications for health education. Prerequisite: Hl.Ed. 501.

PHYSICAL EDUCATION (PH ED)

400. Adapted Physical Education (3)
402. Physical Education for Children with Learning Problems (2)
420. Psychosocial Dimensions of Physical Activity (3)
450. Current Research Literature in Physical Education (3)
452. Analysis of Physical Education Activities for the Elementary School (3)
455. Statistical Methods in Health, Physical Education, and Recreation (3)
456. Physical Fitness Appraisal (3)
460. Methods and Principles of Athletic Coaching (3)
462. Administration of Athletic Programs (2)
470. History and Theory of Dance in Education (2)
471. European and American Folk Dance (2)
480. Exercise Physiology (3)
483. Motor Patterns of Children (3)
484. Kinesiology (3)
489. Intramural Athletics (3)
490. Introduction to Tests and Measurements in Health and Physical Education (3)
491. Organization and Administration of Health and Physical Education in Schools (3)
495. History of Sport in American Society (3)
496. Special Projects (1-6)
497. Sport in Antiquity (3)

500. (Rc.Pk. 500) Individual Study and Research Projects (1-10) Prerequisite: Ph.Ed. 530.

520. Psychology of Sport (3) Study of man's psychological behavior in sport and physical activity; development of somatopsychic theory of physical activity. Prerequisite: 6 credits in psychology.

522. Sport in Society (3) Examination of the cultural phenomenon of sport; social behavior in sport; institution of sport and relationship with other social institutions. Prerequisite: 3 credits in sociology.

530. (Rc.Pk. 530) Research Techniques in Health and Physical Education and Recreation (3)

532. Tests and Measurements in Physical Education (3) Critical study of tests and measurements available in physical education; methods of constructing and evaluating new tests and measurements. Prerequisite: Ph.Ed. 490.

534. Studies in Curriculum Construction in Physical Education (3) Principles and methods of curriculum building in physical education; different psychological and educational points of view, organizing a course of study committee, making units of instruction.

535. Modern Foreign Systems of Sport and Physical Education (3) Comparative analysis of national and local programs and systems of physical education in foreign countries. Prerequisites: Ph.Ed. 534, 595.

550. Seminar in Health and Physical Education (1-6) An in-depth analysis of current problems confronting the profession.

560. Administrative Problems of Physical Education in Schools (3) Solutions to problems emerging from the administration of physical education in schools, fitting physical education in the school's schedule, awards and budgets. Prerequisite: Ph.Ed. 491.

563. Motor Learning (3) Analysis of research evidence related to motor skills; characteristics of beginning and advanced performers; relevant learning principles.

565. Neuromuscular Performance (3) Integrative action of the neural and muscular systems in effecting human movement with emphasis on motor performance. Prerequisites: Ph.Ed. 480, 490.

575. Motor Performance of the Handicapped (3) Motor performance of physically handicapped and mentally retarded. Activities and therapeutic exercises for the formulation of individualized programs. Prerequisites: Cn.Ed. 409, E.E.C. 410.

576. Internship in Adapted Physical Education (3) Supervised internship in recreational, educational, or clinical situations; assessment of motor performances, evaluation of activities, and staff conference participation.

581. Biomechanics (3) Kinetic and kinematic analyses of human motion utilizing electromyography and stroboscopic-photographic techniques. Prerequisite: Ph.Ed. 480.

582. Advanced Kinesiology (3) Analysis of sports movements utilizing cinematography, electronic devices, and related research instruments.

583. Special Topics in Biomechanics (1-6) Critical review of current research in biomechanics, culminating in individual research projects. Prerequisite: Ph.Ed. 581 or 582.

584. Electromyographic Kinesiology (3) The theoretical background and practical application of electromyography in understanding human movement and the function of muscles. Prerequisites: Ph.Ed. 480, 484.

585. (Phsio. 585) Applied Physiology (3) Presentation of current thinking on physiological mechanisms with emphasis on physically active man. Prerequisite: 3 credits in physiology at the 400 or 500 level.

586. Research Methods in Applied Physiology (3) Historical and current procedures for evaluation of cardio-pulmonary function, metabolism, and thermal balance in man; lecture, demonstration, and student laboratory. Prerequisite: 3 credits in physiology at the 400 or 500 level.

588. Special Topics in Applied Physiology (1-6) Critical discussion and evaluation of current research in applied physiology. Prerequisite: Ph.Ed. 585.

589. (Phsio. 589) Physiology of Pulmonary Respiration (2) Physiology of the lung including physical and chemical properties, synthesis of cellular constituents, gas exchange, and effects of unusual environments. Prerequisite: 3 credits of physiology at 400 or 500 level.

595. Philosophy of Sport and Physical Education (3) Prerequisite: Ph.Ed. 491 or Rc.Pk. 465.

PHYSICAL SCIENCE (PH SC)

Thomas A. Wiggins, *Chairman of the Committee on Physical Science*
S-6 Osmond Laboratory

Degrees Conferred: D.Ed., M.Ed.

The M.Ed. program, designed to meet the needs of secondary school science teachers, requires at least 24 credits chosen from chemistry, physics, astronomy, mathematics, earth sciences, and biological sciences, including at least 9 each in chemistry and physics. In addition, a minor of at least 6 credits in education is required. The student must also complete a satisfactory term paper on a subject approved by the committee.

For admission to either the M.Ed. program or the D.Ed. program, the student is expected to have completed two years of college chemistry, one year of college physics at a level requiring calculus, mathematics through differential equations, and 18 credits in appropriate education and psychology courses.

For the D.Ed. degree, the student is required to complete 24 credits in physical science, including chemistry, earth sciences, mathematics, and physics, which *may* be (but are not required to be) in courses designed specifically for teachers. He is expected, beyond this, to complete 36 credits in standard 400- and 500-level courses, which *may not* be courses designed primarily for teachers; of these, 12 credits must be in chemistry, 12 in physics, and 12 in science and mathematics courses approved by the student's doctoral committee. In addition, 15 credits

in education courses and 15 credits of thesis research are required. The student's selection of science courses should include at least 6 credits in experimental physics or chemistry.

A limited amount of work can be done during summer terms or off campus, but a candidate must plan to be on the University Park Campus for at least four consecutive terms after he has been accepted as a D.Ed. candidate. The student will be required to take a candidacy examination after having completed about 30 credits of graduate study, and a comprehensive examination after having completed his required course work. He must also present and defend a thesis, which may be either an experimental study in physics or chemistry, or an investigation of a problem in the teaching of physical science.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

See also Earth Sciences, Mathematics, and Physics.

PHYSICS (PHYS)

ROLAND H. GOOD, JR., *Head of the Department*
104 Davey Laboratory

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Atwater, Barsch, Bleuler, Cutler, Eastman, Feuchtwang, Fleming, Frankl, Freed, Henisch, Herman, Kazes, Kendall, Lang, Madjid, McCammon, McCubbin, McKelvey, Müller, Pliva, Polo, Pratt, Skudrzyk, Strother, Thwaites, Vedam, Weber, Whitfield, and Wiggins.

Graduate Faculty: Associate Members Graetzer, Grotch, Lochstet, Nishikawa, Reed, Rendulic, Shaw, and Tsong.

Graduate instruction and research opportunities are available in atomic and molecular physics, lasers, field emission microscopy, many aspects of solid-state and surface physics, low-temperature physics, ionosphere and vacuum physics, acoustics, physics of biological crystals and compounds, nuclear physics, theoretical particle physics, quantum field theory, and general relativity. Work in some areas is conducted in cooperation with the Department of Biophysics, the Materials Research Laboratory, the Ionosphere Research Laboratory, and the Applied Research Laboratory.

For the Ph.D. degree, knowledge of a foreign language may be required depending on the area of research. For the M.S. and M.Ed. degrees, the nonthesis option is available subject to approval by the department head. The M.Ed. program requires at least 18 credits in physics, which may include up to 6 credits for research, 6 additional nonresearch credits in science, and at least 6 credits in education.

A bachelor's degree in physics or an allied field is required for admission to the M.S., D.Ed., and Ph.D. programs. For admission to the M.Ed. program a student is required to have completed one year of general college physics plus two acceptable intermediate courses in physics, mathematics through integral calculus, and 18 credits in education and related psychology. Students with a 2.50 or higher junior-senior average in physics and mathematics will be considered for admission to the M.S., D.Ed., and Ph.D. programs. For admission to the M.Ed. program, the minimum requirement is a 2.50 junior-senior average in all courses. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. Exceptions may also be made for applicants for doctoral programs who have completed master's degrees at other institutions.

PHYSICS (PHYS)

400. INTERMEDIATE ELECTRICITY AND MAGNETISM (4)

402. Electronics for Scientists (4)
406. Nuclear Physics (3)
410. Introduction to Quantum Mechanics (3)
412. Solid State Physics I (3)
413. Solid State Physics II (3)
419. (A.M. 419) Theoretical Mechanics (3)
420. Thermodynamics (3)
421. Kinetic Theory and Statistical Mechanics (3)
433. Mechanics and Fluid Physics for Teachers (3)
435. Electricity and Magnetism for Teachers (3)
443. Intermediate Acoustics (3)
454. Atomic and Nuclear Physics (3)
456. Atomic and Molecular Physics (3)
457. Experimental Physics (1-2 per term)
458. Intermediate Optics (4)
461. (A.M. 461) Theoretical Mechanics (3)
467. Intermediate Electricity and Magnetism (3)
470. Special Topics (1-9)
471. Quantum Theory of Atoms and Molecules (3)

512-513. Introduction to the Quantum Theory of Solids (3 each) Energy band theory; electrical, optical, and magnetic properties; lattice dynamics; transport theory. Prerequisites: Phys. 412, 517.

517. Statistical Mechanics (3) Classical and quantum statistics; statistical thermodynamics; the Boltzmann transport equation; methods illustrated with applications to physical problems. Prerequisites: Phys. 420, 561.

518. Advanced Topics in Thermodynamics and Statistical Mechanics (3) Selected topics related to nonequilibrium thermodynamics, many-body problem, fluctuations, and statistical theory of random processes. Prerequisite: Phys. 517.

524. Physics of Semiconductors (3) Band structures, theory of electron and hole conduction, transport properties, excess carrier distributions, p-n junctions, metal-semiconductor contacts, semiconductor surfaces. Prerequisite: Phys. 412.

525. Methods of Theoretical Physics (3) Vector and tensor analysis; generalized coordinate systems; matrices and linear vector spaces of finite and infinite dimensionality; calculus of variations. Prerequisite: advanced calculus.

526. Methods of Theoretical Physics (3) Continuation of Phys. 525: complex variables; Hilbert space; Green's functions; orthogonal functions and boundary value problems. Prerequisite: Phys. 525.

530. Theoretical Mechanics (3) Newtonian mechanics; Lagrange's equations, Hamilton's principle; Hamilton's equations; coupled systems; waves in strings, central field problem; rigid bodies; elasticity; hydrodynamics.

532. Advanced Theoretical Mechanics (3) Least action principle, canonical transformations, Lagrange and Poisson brackets, Hamilton-Jacobi equations, classical theory of fields. Prerequisite: Phys. 530.

533. Theoretical Acoustics (3) Vibrating systems; transmission of disturbances through elastic and viscoelastic media. Prerequisite: Phys. 530.

550. (A.M. 550) Applied Group Theory (3) Representations of discrete and continuous groups, applications to theoretical physics and differential equations, varying emphasis on the specific applications. Prerequisite: A.M. 510 or Phys. 525.

553-554. Nuclear Physics (3 each) Discussion and theoretical interpretation of basic experiments involving atomic nuclei and nuclear radiations. Prerequisite: Phys. 562.

557. Electricity and Magnetism (3) Electro- and magnetostatics, Maxwell's equations, boundary value problems, electric and magnetic properties of material media.

558. Advanced Electricity and Magnetism (3) Energy and momentum in the field, radiation theory, classical relativistic electron theory. Prerequisite: Phys. 557.

559. Graduate Laboratory (1) Introduction to techniques and instrumentation used in modern physics laboratories. Includes experience in planning experiments and working in research laboratories.

561-562. Quantum Mechanics (3 each) The basic theory of wave and matrix mechanics, approximation methods, applications. Prerequisite: Phys. 530.

563-564. Advanced Quantum Mechanics (3 each) Relativistic wave equations, quantum field theory, other advanced quantum theoretical topics. Prerequisite: Phys. 562.

571. Atomic Physics (3) Experimental basis of modern physics; atomic spectra and structure, nuclear phenomena.

572. Molecular Physics (3) Electronic and nuclear motions in molecules, molecular spectra and structure. Prerequisite: Phys. 571.

590. Colloquium (1-3)

596. Individual Studies (1-6)

597. Special Topics (1-6)

PHYSIOLOGY (PHSIO)

E. R. Buskirk, *Chairman of the Committee on Physiology*
119 Noll Laboratory for Human Performance Research

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Amann, Anthony, Bardin, Baumgardt, Buskirk, Cornwell, Jefferson, Kollias, Leach, Martin, McCarl, Mendez, Morgan, Mortimore, Mueller, Neely, Rhoades, Smyth, and Wickersham.

Graduate Faculty: Associate Members Eberhart, Gahagan, Hodgson, Hollis, Mitchell, Neff, Nicholas, Rose, Scholz, Wade, Wangsness, and Whitfield.

This is an intercollege program designed to enable students to obtain an integrated series of courses encompassing both the fundamentals of physiology and advanced training in a specialized area.

Graduate instruction in physiology is under the direction of a program committee composed of graduate faculty representing several departments or groups actively participating in the physiology program, including the areas of animal industry, animal nutrition, biochemistry, bioengineering, biology, biophysics, physical education, veterinary science, and zoology. The instructional staff is composed of faculty in those departments offering graduate courses in various areas of specialization in physiology. The program, including courses, laboratory experience, and original research, is designed for completion in three to four academic years. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests.

The entering student who lacks adequate preparation in chemistry, mathematics (through calculus), physics, or biological science must make up the deficiency early in his graduate program. All candidates (master's and doctoral) must complete a general basic laboratory course in physiology (combined cellular, mammalian, and comparative) before choosing an area

of specialization. Possible areas of specialization are cardiovascular and respiratory physiology; cellular and subcellular physiology; comparative physiology; environmental physiology; exercise physiology; physiology of nutrition and metabolism; neurophysiology; and reproductive physiology. The graduate committee for majors shall be appropriately represented by members of the physiology program committee and those of the area of specialization who shall have the responsibility and jurisdiction for determining the course program and research acceptable in satisfying degree requirements. The nonthesis option is available for the M.S. degree.

The following courses, among others, are available for physiology majors, and their descriptions may be found under the offerings of several departments: Agro. 512, 545; A.I. 510, 514; A.Ntr. 401, 402, 501; Anthy. 505, 507; Bioch. 401, 402, 417, 437, 438, 501, 510, 511, 512, 519; Bio.E. 402; Biol. 437, 462, 472, 473, 475, 479, 538, 539, 541; Bphys. 473, 474, 475, 580, 587, 588, 591; Cmp.Sc. 402, 410; D.Sc. 431, 512, 515, 521; Ed.Psy. 400, 406, 506, 507; E.E. 569; Hl.Ed. 511, 513; Meteo. 505; Micrb. 400, 401, 417, 508; Nuc.E. 415, 420; Nutr. 452, 457, 458, 459, 552, 557; Ph.Ed. 456, 480, 565, 586, 588; Phys. 400, 402, 420; Psy. 402, 403, 452, 453, 455, 503; Stat. 451, 461, 462, 464; V.Sc. 405, 525, 528, 535.

The following courses in anatomy, biochemistry, and physiology are offered at The Milton S. Hershey Medical Center: Anat. 505, 510, 512, 535, 542, 543; B.Chem. 502, 503, 513, 523, 540, 553, 590, 597; Phsio. 520, 521, 522, 523, 525, 530, 532, 534, 536, 550, 570, 590. Descriptions of these courses may be found under the designated program.

PHYSIOLOGY (PHSIO)

501. Seminar (1 per term)

532. Reproductive Physiology (3) Physiology of male and female reproductive systems, including synthesis, regulation of secretion and mechanism of action of the steroids and polypeptide hormones involved. Prerequisites: Phsio. 520, 521.

534. Heart and Skeletal Muscle (2) Discussion of structure, chemistry, and physiology of heart and skeletal muscle. Prerequisites: Phsio. 520, 521.

536. Gastrointestinal Physiology (2) Mechanisms of absorption and secretion by stomach, intestine, pancreas, and gallbladder. Neural and hormonal regulation, bioelectric potentials, pathophysiology. Prerequisite: Phsio. 521.

571. (Biol. 571) Animal Physiology (2) Physiology and fluid transport mechanisms; examination of the distribution and regulation of body fluids, blood and hemodynamics. Prerequisite: 3 credits in physiology.

572. (Biol. 572) Animal Physiology (2) Examination of nutrition, metabolism, and respiration as they relate to subcellular, cellular, and organ organizational levels of the whole animal. Prerequisite: 3 credits in physiology.

573. (Biol. 573) Animal Physiology (2) Detailed examination of animal reproduction, endocrine secretion and control, neural-muscular activity, central nervous system correlates, and special senses. Prerequisite: 3 credits in physiology.

574. (Biol. 574) Animal Physiology Laboratory (1-6) Selected problems using advanced physiological techniques to study transport mechanisms, circulation, excretion, respiration, metabolism, and neuroendocrines. Prerequisite: Biol. 473.

585. (Ph.Ed. 585) Applied Physiology (3) Presentation of current thinking on physiological mechanisms with emphasis on physically active man. Prerequisite: 3 credits in physiology at the 400 or 500 level.

589. (Ph.Ed. 589) Physiology of Pulmonary Respiration (2) Physiology of the lung including physical and chemical properties, synthesis of cellular constituents, gas exchange, and effects of unusual environments. Prerequisite: 3 credits of physiology at 400 or 500 level.

590. Colloquium (1-3)

596. Individual Studies (1-6)

597. Special Topics (1-6)

PLANT PATHOLOGY (PPATH)

JAMES TAMMEN, *Head of the Department*
211 Buckhout Laboratory

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members Bloom, Boyle, Cole, Kingsolver, Kneebone, Lewis, Lukezic, Merrill, Mills, P. Nelson, R. Nelson, Oswald, Schisler, Sherwood, Smith, and Tammen.

Graduate Faculty: Associate Members Ayers, Hyre, Leath, Stouffer, and Wuest.

Plant pathology is the study of disease in plants and concerns the dynamic interaction between the plant, the causal agent (bacteria, fungi, viruses, nematodes, etc.), and their environments. A student prepares for a professional career in research, teaching, extension, or industry through advanced studies of the principles of plant infection, the physiology of disease in plants, the ecology of root diseases, the nature and inheritance of disease resistance in plants, epidemiology, ecology and physiology of air pollution injury to plants, or plant disease control by biological or chemical means. A student also may specialize in the nature and control of the diseases of forest trees, agronomic or horticultural crops, and commercial mushrooms. Advanced studies in applied mycology, related to the production of the commercial mushroom, also may be taken. Modern, well-equipped laboratories, controlled environment facilities and greenhouses, and well-developed field research areas are available for graduate study.

The Master of Agriculture degree is offered to provide professional training in plant pathology with more of a crop orientation than is available under the M.S. program. In addition to the courses required for an M.S. degree, further study in the areas of entomology and crop sciences is required. A thesis substitute, such as an internship report, or an adaptive or demonstrative activity whereby known technology or procedures are applied, is acceptable.

Competency in foreign language is not required for the Ph.D. degree; however, depending upon the nature of the thesis research and with the advice and consent of the doctoral advisory committee, competency in a foreign language may be judged to be an essential part of the doctoral studies of certain students.

For admission a student must present 42 credits in the natural sciences, including a minimum of 15 credits in the plant sciences and a minimum of 15 credits in mathematics, chemistry, or physics. Students with a strong background in agronomy, biochemistry, biophysics, botany, forestry, genetics, horticulture, or microbiology are usually well prepared for advanced study in plant pathology.

Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests.

PLANT PATHOLOGY (PPATH)

401. THEORY AND CONCEPTS OF PLANT PATHOLOGY (3) *Messrs. Merrill and Smith*
402. DISEASES OF ECONOMIC PLANTS (2) *Mr. Merrill*
408. PLANT PATHOLOGICAL TECHNIQUES (3) *Mr. Sherwood*
420. PLANT PATHOGENIC BACTERIA (3) *Mr. Lukezic*
422. INTRODUCTION TO PLANT VIROLOGY (3) *Mr. Smith*
424. ENVIRONMENTAL PATHOLOGY (3) *Mr. Davis*
429. PHYTONEMATOLOGY (3) *Mr. Bloom*
430. HISTORY OF PLANT PATHOLOGY (2) *Mr. Merrill*

501. CLINICAL PLANT PATHOLOGY (1-3) Diagnosis and prognosis of disease; observe and evaluate the implementation of control practices. Prerequisite: P.Path. 408. *Mr. Cole*

540. PLANT DISEASE CONTROL (3) Principles of plant disease control, including theoretical considerations involved in control by chemical and nonchemical means. *Mr. Cole*

541. Physiology of Plant Disease (3) Physiology of the diseased plant, including the host response to the pathogen and parasitic properties of the pathogen. Prerequisite: Biol. 443. *Mr. Lukezic*

542. Epidemiology of Plant Diseases (4) Disease development in populations of plants, with emphasis on the impact of environment and control practices on rate of development. Prerequisite: 9 credits in plant pathology.

543. Pathogen Variation and Host Resistance (3) Mechanisms and implications of genetic variation in plant pathogens related to breeding for disease resistance in plants by genetic means. *Mr. Ayers*

544. Pathological Plant Anatomy (2) Structural manifestations occurring in diseased plants. Prerequisites: Biol. 407, P.Path. 408. *Mr. P. E. Nelson*

560. Principles of Plant Pathology (3) Open-ended discussions of concepts of plant pathology, with emphasis on their interrelationships and their significance to the science. *Mr. R. R. Nelson*

590. Colloquium (1-3)

596. Individual Studies (1-6)

597. Special Topics (1-6)

POLITICAL SCIENCE (PL SC)

Robert S. Friedman, *Head of the Department*
112 Burrowes Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Albinski, Aspaturian, Atwater, Brown, Chang, Friedman, Kochanek, and Silva.

Graduate Faculty: Associate Members Eisenstein, Gilberg, Johnson, Keynes, King, Kingsland, Loomis, Myers, O'Connor, Spence, Wikse, and Wissel.

M.A. candidates will be comprehensively examined in American politics, comparative politics, international relations, political philosophy, or public administration. Candidates following the thesis plan will also take course work in one other of these substantive fields, or from among selected empirical theory-methodology courses. Candidates following the nonthesis plan will take course work in two of the above six fields. Ph.D. candidates will be comprehensively examined in four of the above fields, or in three departmental fields, and in a minor field or fields. Course work in empirical theory and scope and methodology is required. The communication and foreign language requirement for the Ph.D. may be satisfied by competence in approved skills selected from among foreign languages, statistics or mathematics, and computer science.

Students with a 3.00 junior-senior average and appropriate course backgrounds, including at least the equivalent of 12 credits in political science, will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. At the master's level two letters of recommendation and scores on the Graduate Record Examination (disciplinary, verbal, and quantitative ability) are required. Admission to the Ph.D. program will entail evaluation of two letters of recommendation, scores on the Graduate Record Examination (disciplinary, verbal, and quantitative ability), and previous scholastic performance.

POLITICAL SCIENCE (PL SC)

401. Political Behavior (3) *Messrs. King and Wissel*
403. The Legislative Process (3) *Messrs. Keynes and Wissel*

409. Quantitative Political Analysis (3)
411. American Political Theory (3) *Messrs. Spence and Wikse*
412. International Organization: Economic and Social Functions (3) *Mr. Atwater*
413. Government and Politics of the Soviet Union (3) *Messrs. Aspaturian, Atwater, and Gilberg*
414. Foreign Policy of the Soviet Union (3) *Mr. Aspaturian*
415. International Organization: Political and Security Functions (3-6) *Miss Loomis, Messrs. Aspaturian, Atwater, and Brown*
416. International Law (3) *Miss Loomis*
417. American Local Government and Administration (3) *Messrs. Johnson and O'Connor*
418. International Relations Theory (3) *Miss Loomis*
419. Bureaucracy and Public Policy (3) *Messrs. Friedman and Johnson*
425. Government and Politics of the American States (3) *Messrs. Friedman and O'Connor*
426. Political Parties (3) *Miss Silva, Mr. King*
427. Political Opinion (3) *Miss Silva, Messrs. O'Connor and Wissel*
431. Ancient and Medieval Political Theories (3) *Messrs. Spence and Wikse*
433. (L.S. 433) The Law of Labor-Management Relations (3)
438. National Security Policies (3) *Mr. Brown*
441. The American Legal Process (3) *Messrs. Eisenstein and Keynes*
442. American Foreign Policy (3) *Miss Loomis, Messrs. Atwater and Brown*
443. Current Problems in American Foreign Policy (3) *Messrs. Atwater and Brown*
444. Government and the Economy (3) *Mr. Wissel*
447. Constitutional Law: The Federal System (3) *Miss Silva, Mr. Keynes*
448. Constitutional Law: First Amendment Freedoms (3) *Miss Silva*
450. Canadian and Australian Politics and Foreign Policies (3) *Mr. Albinski*
451. Comparative Political Analysis (3) *Mr. Albinski*
452. Governments and Politics of Eastern Europe (3) *Mr. Gilberg*
453. Political Processes in Underdeveloped Systems (3) *Messrs. Chang, Kingsland, Kochanek, and Myers*
454. Government and Politics of Africa (3) *Messrs. Brown and Kingsland*
455. Governments and Politics of Western Europe (3) *Mr. Gilberg*
456. Politics and Institutions of Latin-American Nations (3) *Mr. Myers*
457. International Politics of Latin America (3-6) *Mr. Myers*
458. Government and Politics of East Asia (3-6) *Mr. Chang*
459. Government, Politics, and International Relations of South Asia (3) *Mr. Kochanek*
460. Liberal and Democratic Political Theory (3) *Messrs. Spence and Wikse*
461. Authoritarian and Elitist Political Theory (3) *Messrs. Spence and Wikse*
462. Marxist and Socialist Political Theory (3) *Messrs. Spence and Wikse*
468. International Relations of East Asia (3) *Mr. Chang*
469. International Relations of South Asia (3-6) *Mr. Kochanek*
473. Constitutional Law: Civil Rights (3) *Miss Silva*
494. Directed Readings in Political Science (1-6)
495. Directed Research in Political Science (1-6)
499. Foreign Study in Government (2-6)

500. Political Power (3-6) Subject to be announced.
505. Executive Power (3-6) *Miss Silva*
509. Scope and Method of Political Science (3-6) *Mr. King*
512. Comparative Political Systems (3-9) *Messrs. Albinski, Chang, and Kochanek*

513. Seminar in Comparative Political Parties (3-6) Nature, function, organization, and leadership of parties; party systems, political culture, voting, and the institutional framework. *Messrs. Albinski and King*

515. International Politics (3-6)

516. Seminar in International Relations Theory and Methodology (3) A detailed analysis of major traditional and contemporary theory-building efforts and contemporary research techniques and orientations in international relations. *Miss Loomis*

517. International Organization (3-6) *Messrs. Aspaturian and Atwater*

521. Modern Democratic Political Theory (3-6) *Messrs. Spence and Wikse*

522. Comparative Foreign Policies (3-6) Major policies of selected nations which bear upon the search for international peace and security. *Messrs. Aspaturian and Atwater*

523. Soviet Political Behavior (3) Forces which shape rivalries for power; decision-making processes; areas of agreement and dissent. *Messrs. Aspaturian and Gilberg*

524. Foreign Policies of the Soviet Bloc (3-6) Major policies, the decision-making process, and the impact upon component members and external rivals for power. *Mr. Aspaturian*

525. Comparative American State and Local Politics (3-6) Literature and research in comparative state and local political systems in the United States. *Messrs. Friedman and O'Connor*

527. Politics and Legislative Behavior (3-6) Social factors which shape and determine the attitudes and decisions of American legislators and legislative bodies. *Mr. Keynes*

528. (Ed.Adm. 528) Politics and Education (3) Social forces which shape the educational system and determine national, state, and local educational policies.

529. Federal Systems (3-6) Features of the American federal system compared with those of other nations using the federal form.

530. Public Law (3-6) The nature of law and its role in modern society. *Miss Silva, Mr. Eisenstein*

531. Marxism and Political Socialist Theories (3) A systematic analysis and appraisal of major premises and deductions. *Mr. Aspaturian*

532. Empirical Political Theory (3-6) The impact of scientific method upon traditional political thought. *Messrs. Keynes, Spence, and Wissel*

546. Judicial Process (3) Court functions in the political process; sources and limits of judicial power; perceptions of the judicial role; judicial decision making. Prerequisite: 12 credits in political science. *Miss Silva, Messrs. Eisenstein and Keynes*

554. African Political Systems (3-6) Impact of European colonialism; cultural and anthropological factors in political development; modernization and analysis of selected problems in contemporary Africa. Prerequisite: 3 credits of comparative government or international relations at the 400 level. *Messrs. Brown and Kingsland*

572. (Pub.A. 572) International Development Administration (3-6) The execution of foreign policies through national and international public and private organizations. *Messrs. Brown and LaPorte*

573. (Pub.A. 573) Comparative Public Administration (3-6) Administrative systems of selected nations on a functional basis; relationship between culture, economic and social systems, and public administration. *Messrs. LaPorte and Myers*

574. (Pub.A. 574) Seminar in the Administration of United States Foreign Affairs (3) Effect of cross-cultural operations on the normal process of administration of United States foreign affairs. *Messrs. Brown and LaPorte*

586. THEORY OF BUREAUCRATIC AND ADMINISTRATIVE POLITICS (3-6) The role of the executive in government and politics; theories of administrative organization, organization behavior, and decision-making processes. *Messrs. Friedman and Johnson*

594. READINGS IN POLITICAL SCIENCE (1-6) Directed readings in selected areas of the discipline.

595. RESEARCH IN POLITICAL SCIENCE (1-6) Directed research in selected areas of the discipline.

POULTRY SCIENCE (PTYSC)

KENNETH GOODWIN, *Head of the Department*
214 Animal Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Bressler, Buss, Goodwin, Graves, Hale, Leach, MacNeil, and Mueller.

Graduate Faculty: Associate Member Mast.

The department offers two types of graduate programs: (1) a degree in poultry science, with one of the following major fields of interest: genetics, physiology, nutrition, behavior, food science, or poultry management; and (2) an interdepartmental program with a degree in one of the following disciplines: genetics, physiology, food science, animal nutrition, or ecology.

In either case, the student's major program and his thesis research will be under the direction of a faculty member in the Department of Poultry Science. The communication and foreign language requirement for the Ph.D. degree may be satisfied by reading ability in one foreign language.

Admission requirements include 30 credits in biology, chemistry, mathematics, and physics. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

POULTRY SCIENCE (PTYSC)

402. SPECIAL TOPICS (3-12) *Staff*
405. POULTRY PRODUCTION TECHNOLOGY (3) *Mr. Keene*
462. (Biol. 462) ANIMAL BEHAVIOR — ETHOLOGY (3)
463. (Biol. 463, Psy. 463) ANIMAL BEHAVIOR LABORATORY (1-2)

502. ADVANCED POULTRY NUTRITION (2-4) *Mr. Leach*

503. POULTRY FARM MANAGEMENT (3) An analysis of poultry farm management problems and the application of research methods to a specific problem. *Mr. Bressler*

504. POULTRY MEAT AND EGG TECHNOLOGY (3) Analysis of current industry programs, effects of specific procedures on product quality, development of research programs. Offered even years. *Mr. MacNeil*

582. (Biol. 582, Psy. 582) RESEARCH IN ANIMAL BEHAVIOR (2-6 per term) Research in special areas of animal behavior involving field or laboratory work. *Messrs. Graves and Hale*

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

NOTE: *See Animal Science under "Other Elective Graduate Courses." Also see Food Science.*

PSYCHOLOGY (PSY)

MERRILL E. NOBLE, *Head of the Department*
417 Moore Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Cofer, Cornwell, Draguns, Gorlow, Greenhill, Guthrie, Hale, Hall, Harris, Landy, Leibowitz, Lundy, Martin, Mitzel, Noble, Palermo, Piers, Seibel, Sherif, Stern, Taylor, Thevaos, Thomas, Trumbo, Urban, and Warren.

Graduate Faculty: Associate Members Blashfield, Craighead, Dubin, Farr, Kazdin, Kerr, Mahoney, Ravizza, Ray, Seaver, Shotland, Weimer, and Whaley.

Graduate instruction and research opportunities are available in the following areas of psychology: general experimental, physiological and comparative, perception, social and personality, developmental, child, clinical, industrial-organizational, engineering and human factors, verbal learning, and psycholinguistics.

The communication and foreign language requirement for the Ph.D. degree does not specify a foreign language but a student must demonstrate proficiency in English. The nonthesis option is available for the M.S. degree.

Special research and training facilities include the Penn State Anechoic Chamber, the University Computation Center, the Animal Behavior Laboratory, the Psychology Clinic, the Division of Counseling, and the Special Education unit.

Requirements for admission include a broad undergraduate preparation, a minimum of 9 credits in psychology, and a satisfactory graduate student rating on the Miller Analogies Test and the Graduate Record Examination (General). Students with a 3.20 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.20 grade-point average may be made for students with special backgrounds, abilities, and interests. Applicants with master's degrees will have their admission evaluated with emphasis on the quality of their graduate programs.

PSYCHOLOGY (PSY)

402. Sensation and Perception (3)
403. Introductory Physiological Psychology (3)
404. Conditioning and Learning (3)
405. The Experimental Psychology of Visual Perception (3)
408. Comparative Psychology (3)
409. Techniques in Laboratory Experimentation (2-6)
410. Historical Antecedents of Psychology (3)
411. Systems of Psychology and the Recent Past (3)
412. Abnormal Psychology (3)
413. Biographical Psychology (3)
414. Humanistic Psychology (3)
415. Intermediate Experimental Design (3)
417. Social Psychology (3)
418. Measurement of Personality (3)
420. (Ling. 420) Advanced Psycholinguistics (3)
421. Advanced Cognitive Psychology (3)
425. Child Psychology (3)
426. Adolescence (2-3)
430. Memory and Verbal Learning (3)
431. Industrial Psychology (3)
432. Introductory Engineering Psychology (3)
433. Psychology of Occupational Behavior (2)
434. Information-Processing Laboratory (1-6)

436. Mental Health in Schools (3)
437. Psychology of Adjustment (3)
438. Theory of Personality (3)
440. Psychology Projects (1-6)
441. Industrial Motivation and Morale (3)
445. (I.F.S. 445) Development Throughout Adulthood (3)
450. (Ed.Psy. 450) Principles of Measurement (3)
452. Laboratory in Sensory Processes (2-4)
453. Neuroanatomy Laboratory (1)
455. Physiological Psychology Laboratory (3)
456. Laboratory in Psychophysiology (2-4)
457. Experimental Social Psychology (4)
463. (Biol. 463, Pty.Sc. 463) Animal Behavior Laboratory (1-2)
474. Psychology of Exceptional Children (3)
482. Introduction to Clinical Psychology (3)

500. Seminar: Introduction to Graduate Study (2-6) Required of all new graduate majors in psychology.

503. Physiological Psychology (2-6) Correlations between structure and function of nervous system and human consciousness; laws and theories in fields of sensation, attention, association, affection, and thought. Prerequisite: 9 credits in psychology.

505. Research Problems in Psychology (1-15) Prerequisite: 12 credits in psychology.

509. Seminar in Conditioning and Learning (3-9) Prerequisite: Psy. 404 or Ed.Psy. 421.

510. History of the Higher Mental Processes (3) Stress upon theoretical, conceptual, and methodological problems involved in studying human thinking, language, memory, cognition, and other skills. Prerequisite: Psy. 410 or 411.

511. Seminar in Contemporary Psychology (1-9) Critical review of readings on a topic of current interest, either in content or methodology, within psychology. Prerequisite: 9 credits in psychology.

513. (Phil. 513) Principles and Methods of Empirical Science (3) Scientific methodologies and their presuppositions, with special emphasis on behavioral and social sciences.

515. Advanced Statistics in Psychology and Education (3) Correlation theory and methods, discriminant function, and factor analysis; applications to mental test theory. Prerequisite: Psy. 415 or Ed.Psy. 506.

516. Seminar in Quantitative Models (3-9)

517. Advanced Social Psychology (3) Problems of theory and of research methods with emphasis on persisting issues relevant to contemporary developments in social psychology. Prerequisites: Psy. 417; Psy. 15 or Stat. 200.

518. Projects in Experimental Psychology (2-4) Individual experimental projects; seminars on experimental design and instrumentation.

520. (Ling. 520) Seminar in Psycholinguistics (3) Consideration of theoretical and research issues relevant to psychological aspects of language sounds, syntax and semantics and their cognitive support.

527. Statistical Inference and Experimental Design (3) Probability theory, sampling distributions, analysis of variance and covariance, analysis of trend, nonparametric statistics, experimental design. Prerequisite: Psy. 415 or Ed.Psy. 506.

529. (I.F.S. 529) Seminar in Child Development (1-6) Readings and reports on recent findings in child development. Prerequisites: 6 graduate credits in child development, child psychology, or educational psychology, plus 3 in statistics.

531. Seminar in Performance Theory (3-9) Topics in theory and research on human performance in perceptual-motor and information-processing tasks. Prerequisite: Psy. 432.

533. Seminar in Engineering Psychology (2-9) Design and operation of machines, man-machine allocation, the man-machine interface, displays, system-design, decision making, image evaluation, and motor behavior. Prerequisite: Psy. 432.

535. Developmental Psychology (2-3) Developmental principles and concepts applied to psychological processes, with special reference to the experimental literature. Prerequisite: 9 credits in psychology.

536. (I.F.S. 536) Research Methods in Developmental Processes (3) Methodological issues in research on varying stages of development across the individual life-span. Prerequisites: 6 credits in individual development or psychology and a course in statistics.

537. Seminar in Industrial Psychology (1-9) Prerequisite: Psy. 431.

538. Psychology of Personnel Development (3) Industrial training in relation to psychological learning theory and experimental findings. Prerequisite: Psy. 431 or Ed.Psy. 421.

539. Seminar in Motivation and Emotion (3-9) Systematic status of instinct, drive, motive, will, purpose; methodology and results of physiological, experimental, and clinical investigation of basic drives.

540. Seminar in Clinical Problems (1-9) Contemporary psychological theory, research, and methodology in relation to clinical psychology. Prerequisites: Psy. 542, 560.

541. Personality Theory (3-4) Contemporary theories of personality; relevant research. Prerequisite: Psy. 438.

542. Psychopathology (3-4) Theories of pathological behavior with reference to clinical and experimental data. Prerequisite: Psy. 412.

545. Seminar in Verbal Learning and Verbal Behavior (1-9)

549. (I.F.S. 549) Developmental Theory (3) Conceptual frameworks and major contributions to the study of individual development across the life-span. Prerequisite: 6 credits at the 400 level in individual development or psychology.

555. Theory and Practicum in Clinical Assessment (3-9) Theoretical issues and research in clinical assessment with special reference to administration and interpretation of testing procedures and clinical interviewing. Prerequisites: Psy. 541 or 542, and a course in measurement.

558. Clinical Child Psychology (3-9) Psychopathology of childhood; theories of etiology; diagnosis and treatment. Prerequisites: Psy. 555, 561.

559. (S.Psy. 559) The Individual Psychological Examination (3) Demonstrations and practice in widely used ability and aptitude tests; psychological report writing. Prerequisites: 15 credits in psychology and a course in measurement.

560. Practicum in Clinical Methods (1-6) Supervised practice in the Psychology Clinic, including assessment, therapy, report writing, and staff participation. Prerequisite: Psy. 555.

561. Clinical Practicum with Children (1-6) Diagnosis and counseling of child-parent problems of learning and adjustment. Prerequisites: Psy. 425, 426, 555.

569. Advanced Theory and Practicum in Counseling and Psychotherapy (3-9) Theoretical issues, research, and practicum experience in psychotherapy.

571. Seminar in Social Psychology (3-9) Historical development of theory and methods; determinants and principles of complex social or interactional behavior; contemporary problems and research.

580. Theory and Construction of Attitude Scales (3) Measurement of social, political, commercial, and industrial attitudes; questionnaire designs. Prerequisite: 3 credits in statistics.

581. Experimental Study of Primate Behavior (3) Taxonomy of contemporary species of primates; ontogeny of learning, perception, and affective behavior; interspecies comparisons of behavior.

582. (Biol. 582, Pty.Sc. 582) Research in Animal Behavior (2-6 per term) Research in special areas of animal behavior involving field or laboratory work.

589. Problems in Clinical Research (1-6) Prerequisite: Psy. 415.

590. Colloquium (1-3)

591. Seminar on Teaching Psychology (1-3) Objectives and content of psychology; organization and presentation of material; teaching aids and techniques.

596. Individual Studies (1-6)

597. Special Topics (1-6)

PSYCHOSOCIAL SCIENCE (PS SC)

JOHN R. NICHOLS, *In Charge of Graduate Program in Psychosocial Science*
The Capitol Campus, Middletown, Pa. 17057

Degree Conferred: M.Ps.Sc.

Graduate Faculty: Senior Members Hudson, Lear, Nichols, and Whittaker.

Graduate Faculty: Associate Members Colman, Dexter, Fleishman, Knestrick, and Starkey.

The program emphasizes practicum experience to equip students with necessary skills to cope effectively with the problems facing communities. Graduates of the program should be able to recognize problems, to outline and implement possible solutions to these problems, and to evaluate the effectiveness of the solutions. To perform these functions the student must be aware of contemporary community needs, the impact of the community structure upon its individual members, and the techniques best suited to initiate productive change. Problems in drug abuse, delinquency, unemployment, housing, and other areas affecting the individual may be approached from a community agency base or from less formal community groups dealing with the problems.

The student is required to take 33 credits, 21 at the 500 level. The required practicum experience is field work under the supervision of a faculty member. A paper is required and will be defended orally before a committee of two faculty members and a staff member from the practicum site.

For admission, a student must have received a baccalaureate degree from an accredited institution with residence and credit conditions substantially equivalent to those required by The Pennsylvania State University. Most applicants will have degrees in psychology or sociology; however, experience in community agencies will be weighted for applicants from other disciplines. Ordinarily, applicants are expected to be familiar with elementary statistics and may be requested to make up any deficiency without graduate credit. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Required courses include: So.Sc. 510, 520; Ps.Sc. 511, 521, 530. Elective courses for a public agency emphasis are: So.Sc. 541, 542, 543. Elective courses for a community organizing emphasis are: So.Sc. 531, 532, 533.

Additional courses may be taken from the following list and from any other graduate course list with the approval of the student's adviser: Admin. 500, 510, 550, 551, 560; Geog. 420; Ps.Sc. 401, 403, 421, 430, 461, 464, 596, 597; Pub.A. 575; R.Pl. 400; and So.Sc. 443, 590. Descriptions of these courses not given below may be found under the designated fields of study.

This program is offered only at the Capitol Campus. Details of application procedures should be requested from Admissions, The Capitol Campus, Middletown, Pa. 17057.

PSYCHOSOCIAL SCIENCE (PS SC)

401. Seminar in Psychosocial Science (3)

403. Abnormal Psychology (3)
421. Behavior Modification (3)
430. Sociocultural Change (3)
461. Introduction to the Techniques of Counseling (3)
464. Accountability of Public Bureaucracies (3)

511. Psychopathology in a Social Context (3) Psychopathology in the context of other forms of social deviancy, with attention to both social and individual concomitants of deviancy.

521. Practicum (3-9) Experience in a field setting with problems confronting both clients and social welfare agencies. Prerequisites: So.Sc. 510, 520.

530. Research (1-6) Supervised research on a master's paper. For degree candidates only. An *R* grade may be used for research in progress.

596. Individual Studies (1-6)

597. Special Topics (1-6)

SOCIAL SCIENCE (SO SC)

440. The City (3)
443. Social Conflict (3)

510. Change Processes (3) Social change as it takes place within institutions and communities.

520. Techniques in Action Research (3) Methods for evaluating programmatic change. Prerequisite: So.Sc. 320 or equivalent.

531. The Functioning Neighborhood (3) A study of small communities and techniques for observing them, coupled with field experience in participant observation of a specific neighborhood.

532. Community Organizing: Conflict and Change (3) The development of local issues and strategies for organizing around them.

533. Problems of the Disenfranchised (3) Problems confronting minority or low-power groups, with an emphasis on the poor, blacks, and women.

541. The Organization of Human Services (3) Divisions of labor among social agencies; internal and external factors affecting the ordering of priorities.

542. Social Stratification (3) Empirical and theoretical examinations of inequalities in wealth, prestige, and power.

543. Complex Organizations: Change and Resistance (3) Structure and function in large organizations and case studies of change.

590. Colloquium (1-3)

PUBLIC ADMINISTRATION (PUB A)

Robert J. Mowitz, *Director of the Institute of Public Administration*
211 Burrowes Building

Degree Conferred: M.P.A.

Graduate Faculty: Senior Members LaPorte, Mowitz, and Riew.

Graduate Faculty: Associate Members Lee, Lucianovic, Poister, and Westby.

All candidates take a core program consisting of seven seminars which cover the theoretical, methodological, and technological components of public management science. An additional

9 hours may be elected, permitting the student to focus upon such areas as general public administration, systems analysis, management information systems, urban systems administration, natural resources administration, human resources administration, or any other related substantive area.

Candidates for admission ordinarily will have at least 12 hours of undergraduate credit in the social sciences. Candidates for the degree may be required to take some courses without graduate credit in order to complete a major designed for their professional needs.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. Scores from the Graduate Record Examination (aptitude test) are required.

PUBLIC ADMINISTRATION (PUB A)

403. PUBLIC MANAGEMENT TECHNOLOGY (3) *Messrs. LaPorte and Lee*
404. URBAN MANAGEMENT (3) *Messrs. Lee, Lucianovic, and Poister*
445. ADMINISTRATIVE LAW (3) *Messrs. Lee and Mowitz*

570. ADMINISTRATION IN MULTI-JURISDICTIONAL SYSTEMS (3) Analysis of multi-jurisdictional constraints on administration; design of strategies for developing and executing programs in a pluralistic institutional setting. *Mr. LaPorte*

571. THEORY OF PUBLIC ADMINISTRATION (3-6) The role of the executive in modern government; the objectives of public administration; theories of administrative organization and practice. *Mr. Mowitz*

572. (Pl.Sc. 572) INTERNATIONAL DEVELOPMENT ADMINISTRATION (3-6) The execution of foreign policies through national and international public and private organizations. *Messrs. LaPorte and Poister*

573. (Pl.Sc. 573) COMPARATIVE PUBLIC ADMINISTRATION (3-6) Administrative systems of selected nations on a functional basis; relationship between culture, economic and social systems, and public administration. *Messrs. LaPorte and Poister*

574. (Pl.Sc. 574) SEMINAR IN THE ADMINISTRATION OF UNITED STATES FOREIGN AFFAIRS (3) Effect of cross-cultural operations on the normal process of administration of United States foreign affairs. *Messrs. LaPorte and Poister*

575. GOVERNMENT MANPOWER MANAGEMENT (3) Government personnel systems; current trends and problems; essentials of recruitment, classification and pay, ratings, supervision, training, and discipline. *Messrs. LaPorte and Lee*

576. GOVERNMENT FISCAL DECISION MAKING (3) The role of the executive in fiscal planning; budget preparation; expenditure control; tax assessment and collection; investment of public funds. *Messrs. LaPorte and Lee*

577. ORGANIZATION AND SYSTEMS MANAGEMENT (3) Principles of government organization; management surveys; work measurement; methods of achieving efficiency and economy. *Mr. Mowitz*

578. URBAN ADMINISTRATIVE SYSTEMS (3) Urban areas as administrative and policy systems; urban responses to problems of policy planning and implementation; approaches to urban analysis. *Mr. Lee*

579. METHODS OF ANALYSIS AND MEASUREMENT IN PUBLIC ADMINISTRATION (3 per term, maximum of 6) Examination and application of analytical techniques for evaluating organizational performance and program effectiveness in government agencies. *Messrs. Lucianovic and Poister*

580. INTERNSHIP IN PUBLIC ADMINISTRATION (6) *Mr. Mowitz*

581. PUBLIC MANAGEMENT INFORMATION SYSTEMS (3) Examination of the role of management information in public organizations; establishment of information requirements for public programs. Prerequisites: Pub.A. 571, 579. *Mr. Lucianovic*

584. RESEARCH SEMINAR IN PUBLIC ADMINISTRATION (1-6) Application of research methods to problems of organization, management, and policy in public agencies; preparation of research project and report. *Mr. Mowitz*

PUBLIC ADMINISTRATION (P ADM)

DANIEL M. POORE, *Chairman, Public Administration Program*
The Capitol Campus, Middletown, Pa. 17057

Degree Conferred: M.P.A.

Graduate Faculty: Associate Members Bresler, Gilmore, Masters, McKenna, Poore, Skok, and Woodruff.

This program is intended for individuals who are seeking or are currently engaged in professional careers as administrators, project directors, or staff analysts in urban and municipal government, state government, health and welfare organizations, and other public service agencies. In order to complete a program designed for their professional needs, students may be required to complete courses, not for graduate credit, in quantitative methods, accounting/finance, economics, and computer methods. In addition, students must have sufficient preparation in political science and other social sciences, or equivalent experience, in order to perform satisfactorily in the program.

At the graduate level all students take 12 credits of common core courses including administrative theory, the political process, statistical research methods, and a professional master's paper. In addition, 18 credits of electives are required in such areas as program planning and evaluation, personnel management, labor relations, fiscal management, urban problems, regional planning, current economic issues, quantitative decision-models, public policy, health administration, and other related areas.

Students with a 2.75 junior-senior average will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.75 grade-point average may be made for students with special backgrounds, abilities, and interests. Applicants are required to present their scores on the aptitude part of the Graduate Record Examination as part of their application materials.

Courses applicable to this program are listed under the program in administration at the Capitol Campus.

RECREATION AND PARKS (RC PK)

KARL G. STOEDEFALKE, *Associate Dean for Graduate Study and Research*
275 Recreation Building

Degrees Conferred: M.S., M.Ed.

Graduate Faculty: Senior Members Harris, Nelson, Stoedefalke, and van der Smissen.

Graduate Faculty: Associate Members Christiansen, Kuss, Lundegren, and Mobley.

The graduate program is designed to prepare students for administrative, supervisory, research, and teaching positions in public recreation and park systems, in colleges and universities, in voluntary agencies, and in institutions.

The program is oriented to meet the specific needs and research interests of the candidate. Areas of specialization include: (1) community-related — including public park and recreation systems, quasi-public and voluntary agencies, and private enterprises; (2) therapeutic recreation — involving both institution and community-oriented settings concerned with many different disabilities and utilizing a variety of activity modalities; and (3) outdoor-related — encompassing camping and outing activities, park planning, interpretive services, outdoor education, and outdoor recreation services.

The master's degree may be earned in the major program of recreation and parks. At the doctoral level, the Ph.D. and D.Ed. may be earned with a specialization in recreation and parks within the physical education major. Write for details.

For admission to the graduate program, a bachelor's or master's degree is required in recreation, park administration, or in a related field, e.g., forestry, landscape architecture, sociology, psychology, physical education, education, or fine arts. Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests.

RECREATION AND PARKS (RC PK)

420. Outdoor Recreation (3)
425. Interpretive Services (3)
430. Outdoor Education (3)
440. Camp Administration (3)
456. Recreation Program Organization (3)
458. Dynamics of Recreation Groups (3)
461. Community Recreation (3)
465. Administration of Recreation and Parks (3)
470. Metropolitan Park Management (3)
475. Therapeutic Recreation in the Community (3)
477. Therapeutic Recreation in the Rehabilitation Setting (3)
496. Special Projects (1-6)

500. (Ph.Ed. 500) Individual Study and Research Projects (1-10) Prerequisite: Rc.Pk. 530.

515. Program Development and Supervision (3) Critical analysis of the individual, political, and societal determinants of recreation programming; demonstration projects; evaluative procedures, research functions in programming. Prerequisite: Rc.Pk. 456.

520. Seminar in Camp Administration (3) Values inherent in the camp experience; critical analysis of philosophical choices and sponsor objectives as influencing program development. Prerequisite: Rc.Pk. 230 or 430.

530. (Ph.Ed. 530) Research Techniques in Health and Physical Education and Recreation (3)

533. Recreation Studies, Surveys, and Appraisals (3) Advanced research procedures related to special recreation and park problems. Prerequisites: Rc.Pk. 530 and 3 credits in statistics.

540. Public Recreation Lands (3) Planning recreation lands; legislation, financing, intergovernmental coordination to acquire and develop open space land, urban recreation and park master plan.

550. Seminar in Recreation and Parks (1-6)

560. Administrative Problems of Recreation and Parks (3) Special problems of recreation and park departments; legal powers and liability; departmental organization, financing, personnel policies, and staff development. Prerequisite: Rc.Pk. 465.

595. PHILOSOPHICAL AND SOCIAL BASES OF RECREATION (3) Philosophical and social bases of recreation; analysis of critical issues of recreation for philosophical and social implications.

REGIONAL PLANNING (R PL)

HARRY S. COBLENTZ, *Chairman, Graduate Program in Regional Planning*
213 Willard Building

Degree Conferred: M.R.P.

Graduate Faculty: Senior Members Buck, J. Coyle, Gamble, Larson, Lee, Miller, and Newman.

Graduate Faculty: Associate Members Coblentz and Griffin.

The objective of this interdisciplinary program is to train professional planners who will be aware of the needs of citizens so that they can develop programs for sound social, political, economic, and cultural advancement through the enlightened management of all resources. The nonthesis option is available for this degree. For admission a student should have had at least one course each in sociology, political science, economics, and statistics and at least one course each in any two of the following subjects: geography, cartography, and public administration. Applicants must submit scores on the Graduate Record Examination with their applications. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered up to the number of spaces available. Exceptions to the 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

REGIONAL PLANNING (R PL)

400. PRINCIPLES OF REGIONAL PLANNING (3-6)
410. PLANNING PROGRAMS (3)
440. PROBLEMS IN COMMUNITY AND REGIONAL PLANNING (1-9)

502. REGIONAL SYSTEMS ANALYSIS (3-6) Spatial structure of regional and interregional systems. Theories of regional development. Spatial measures of location, density, central tendency and dispersion.

503. THEORY AND METHOD OF PLANNING (3) Analysis of normative models of planning processes: social, economic, political and behavioral assumptions, and methodological problems of evaluatory planning performance.

510. PLANNING TECHNIQUES AND ANALYSIS I (3) Regional socioeconomic structure, problems, and factors in planning; data collection, analysis, and implications.

520. PLANNING TECHNIQUES AND ANALYSIS II (3) Interaction of man and environment; land and water resources in regional planning; environmental factors as planning parameters.

530. PLANNING TECHNIQUES AND ANALYSIS III (3) Effects of political, cultural, and physical factors on planning.

540. PROBLEMS IN REGIONAL PLANNING (1-9) Planned individual projects involving library, laboratory (studio), or field work.

RELIGIOUS STUDIES (RL ST)

LUTHER H. HARSHBARGER, *Head of the Department*
1017 Liberal Arts Tower

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Cherry, Fukuyama, Harrison, and Harshbarger.

Graduate Faculty: Associate Member Vastyan.

The emphasis of this program is on the comprehensive understanding of the various facets of religion in American culture. A broad cross-disciplinary scope is encouraged in substantive areas with particular emphasis on the development of religious thought and movements and the relationships between religion and society. The student will share responsibility with the faculty in shaping his program.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by an intermediate knowledge of two foreign languages, by substitution of courses from other designated areas for one of these languages, or by a comprehensive knowledge of one foreign language.

Applications will be evaluated on the basis of the quality of undergraduate, graduate, or professional records and on the basis of the candidate's clarity of understanding and interest in the specific emphases of the program. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. Graduate Record Examination scores, letters of recommendation, and a statement of the applicant's career goals and academic interests will be required.

RELIGIOUS STUDIES (RL ST)

402. SEMINAR IN CONTEMPORARY RELIGIOUS THOUGHT (3-6)
408. HINDUISM (3)
409. BUDDHISM (3)
421. CULTURE AND RELIGIOUS REFORM (3)
422. RELIGION AND AMERICAN CULTURE (3-6)
430. RELIGION AND MORALITY (3)
438. (Soc. 438) RELIGION AND URBAN SOCIETY (3)
440. PROBLEMS IN RELIGION (3-6)
446. (L.Ed. 446) WESTERN RELIGIOUS LITERATURE FOR SECONDARY SCHOOL TEACHERS (3)
447. (L.Ed. 447) EASTERN RELIGIOUS LITERATURE FOR SECONDARY SCHOOL TEACHERS (3)
461. (Soc. 461) SOCIOLOGY OF RELIGION (3)

500. THEORIES OF RELIGION (3-6) Cross-disciplinary study of two or more systematic theories of religion: anthropological, phenomenological, philosophical, psychological, sociological, or theological.

502. STUDIES IN COMPARATIVE RELIGIONS (3-6) Cross-cultural comparative studies of two or more world religions.

505. SEMINAR IN ASIAN RELIGIONS (3-6) Studies in selected Asian religions.

521. ISSUES IN WESTERN RELIGION (3-6) Seminar. Study of selected issues in Western religion.

522. ADVANCED STUDIES IN AMERICAN RELIGION (3-6) In-depth inquiry into either a period, a movement, or a topic of American religion.

524. MAJOR WESTERN RELIGIOUS THINKERS (3-6) Systematic inquiry into the religious thought of major Western religious thinkers.

530. RELIGION AND SOCIETY (3-6) Studies of mutual influences and effects of religion and secular phenomena.

532. Religion and Social Problems (3-6) Study of a selected social issue, or constellation of issues, with analysis of its religious and normative dimensions.

536. Religious Structures and Processes (3-6) Study of the relationship between religion as social structure and as a dynamic social function.

539. Advanced Studies in Religious Ethics (3-6) A systematic study of the structure and essential themes of ethics of religious institutions and thinkers.

590. Colloquium (1-3)

596. Individual Studies (1-6)

597. Special Topics (1-6)

RURAL SOCIOLOGY (R SOC)

Lee M. Day, *Head of the Department of Agricultural Economics and Rural Sociology*
6A Weaver Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members Bealer, Brown, Smith, and Willits.

Graduate Faculty: Associate Members Crawford, Crider, Heasley, Leadley, Stokes, Warland, and Wilkinson.

In all degree programs emphasis is on a comprehensive understanding of the various facets of societal organization pertinent to the rural sector. While scope is encouraged, there are available certain areas of special interest and research: consumer behavior, instigated social change, community structure, human resource development, migration, adolescent behavior, the culture of poverty, and the ecology of rurality in industrialized and urbanized society. All students are required to have training in sociological theory, statistics, and research methods.

There is no foreign language requirement for the Ph.D. degree; the student is expected to substitute such courses and instruction necessary to generate superior capabilities of inquiry into an analysis of basic and/or applied rural sociological problems.

The entering student in the master's program should have as prerequisites 3 credits in rural sociology, 3 credits in sociology, and 3 additional credits in either field. If he does not have these prerequisites, he may take them at the University during the early part of his master's program.

Students with a 2.75 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.75 grade-point average may be made for students with special backgrounds, abilities, and interests.

RURAL SOCIOLOGY (R SOC)

401. Special Topics in Rural Sociology (1-6)
402. Consumer Behavior and the Agricultural Industry (3) *Mr. Herrmann*
405. Leadership for Social Change (3) *Mr. Smith*
425. Poverty Analysis: People and Programs (3) *Messrs. Cordes and Smith*
444. The Rural Transition in American Society (3) *Mr. Leadley*
452. Rural Organization (3) *Mr. Wilkinson*
456. Rural Community Services (3) *Mr. Crawford*
459. Rural Social Psychology (3) *Mrs. Willits*

501. Development of Rural Sociology (2) Historical development with emphasis on American rural sociology.

502. Advanced Rural Sociology (3) Structure and functioning of rural society; evaluation of theoretical systems.

510. Rural Migration (2) Rural migration research and theory; application to governmental and community problems.

513. Sociology of Consumer Behavior (2) Sociological theory and research pertaining to consumer behavior.

514. Values in Rural Society (2) Values as dynamic forces in rural society.

515. Extension Organization and Methods (2) Agricultural and home economics extension as a social system, with emphasis on techniques of organization and program development.

516. Change in Rural Society (2) Social change in rural society, emphasizing prediction and control of the change process.

551. Rural Sociology Seminar (1-6) Prerequisite: 6 credits in rural sociology, sociology, or psychology.

SANITARY ENGINEERING (S E)

Raymond E. Untrauer, *Head of the Department of Civil Engineering*
212 Sackett Building

Degrees Conferred: M.S., M.Eng.

Graduate Faculty: Senior Members McDonnell, Nesbitt, and Unz.

Graduate Faculty: Associate Members Long and Regan.

The entering student normally should be a graduate in engineering from an accredited college of engineering. A student wishing to obtain a Ph.D. degree may major in civil engineering with emphasis on sanitary engineering.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

The following courses offered by the Department of Civil Engineering are appropriate for students majoring in sanitary engineering (course descriptions are given under Civil Engineering): C.E. 451, 452, 462, 465, 471, 472, 476, 551, 553, 564, 571, 572, 573, 574, 575, 576, 577, 579, and 580. Appropriate courses offered by other departments include: Ag. 400; Ag.Ec. 422, 505; Bioch. 401, 402, 425; Biol. 410; Chem. 405; Cmp.Sc. 402; Geol. 452; I.E. 405, 509, 510; M.E. 405, 470, 506, 521, 571; Meteo. 473, 502; Micrb. 400, 417; Nuc.E. 420; Pl.Sc. 419; P.Path. 424; Pub.A. 578; R.Pl. 400, 410, 510, 520.

SCHOOL PSYCHOLOGY (S PSY)

Joseph L. French, *Chairman of the Committee on School Psychology*
102 CEDAR Building

Degrees Conferred: D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members French, Gorlow, Noble, Rabinowitz, and Sabatino.

Graduate Faculty: Associate Members Snyder and Ysseldyke.

This intercollege program is based on courses in the Departments of Psychology, Educational Psychology, and Special Education (developmental and remedial reading, speech pathology and

audiology, and education of exceptional children). Courses may also be drawn from Individual and Family Studies, Counselor Education, Sociology, Cultural Foundations of Education, Educational Administration, and Academic Curriculum and Instruction.

The objective is to develop a psychologist who is interested in and knowledgeable about education and psychology in the school setting. The school psychologist must utilize his professional skills and his knowledge about children and youth to make contributions which are meaningful to and utilized by teachers, other school personnel, and parents. The development of competences needed by a fully qualified school psychologist requires at least the education represented by a doctoral degree. Only those students who anticipate a doctoral degree will be admitted. Exceptions may be made for students with special backgrounds, abilities, and interests. Students are selected within the limitations of departmental facilities. Priority is given to applicants with work experience with children.

An undergraduate major emphasizing work in psychology and/or education is preferred, but students with fewer than 15 upper-division credits in psychology, educational psychology, or special education may be admitted with limited deficiencies to be fulfilled concurrently with their graduate work. Requirements for admission include a minimum junior-senior scholastic average of 2.85 or, for applicants with master's degrees, a minimum of one-third of graduate credits of "A" quality; satisfactory recommendations from two or more professors, preferably psychologists; and 500 or higher on the general sections of the Graduate Record Examination, 58 or higher on the Miller Analogies Test, and/or 35 or higher on the Quantitative Evaluative Device.

Practicum facilities include the Center for Educational Diagnosis and Remediation, the School Psychology Clinic, the Speech Pathology and Audiology Clinic, the Reading Center, the Psychology Clinic, the Campus Demonstration School for handicapped children, and those in nearby public schools. Facilities for work with children are also available through other departments, as well as through assistantship assignments.

Although additional courses from the supporting and other departments are utilized in doctoral programs, core courses from which school psychology students build a program for the school psychologist certificate issued by the Pennsylvania Department of Education are: C.F.Ed. 515; Cn.Ed. 403, 501, 503, 508, 592; D.R.R. 441, 444, 545; Ed.Adm. 480, 576; Ed.Psy. 400, 406, 421, 450, 475, 506, 512, 513, 522, 523, 524; E.E.C. 400, 401, 403, 410, 420, 430, 454, 470, 480, 501, 554; Psy. 404, 412, 417, 418, 425, 426, 541, 542, 555, 558, 559, 561; S.P.A. 440.

SCHOOL PSYCHOLOGY (S PSY)

500. Professional Issues in School Psychology (1-3) Orientation to the field through study of unique problems, current issues, ethical and legal matters, unique cases, and research projects.

504. Practicum in School Psychology (1-6) Clinical experience with children under supervision in a variety of settings requiring service including practice in synthesizing data and observations.

508. Internship in School Psychology (1-10) Long-term placement in settings providing work for school psychologists with children, parents, teachers, administrators, and service agencies under supervision.

510. Supervision of School Psychologists (1-10) Program supervision and professional leadership in University clinics and school systems. Prerequisite: S.Psy. 504.

559. (Psy. 559) The Individual Psychological Examination (3) Demonstrations and practice in widely used ability and aptitude tests; psychological report writing. Prerequisites: 15 credits in psychology and a course in measurement.

596. Individual Studies (1-6)

SLAVIC LANGUAGES AND LITERATURES (S L L)

WILLIAM R. SCHMALSTIEG, *Head of the Department of Slavic Languages*
N-440 Burrowes Building

Degree Conferred: M.A.

Graduate Faculty: Senior Members Birkenmayer, Magner, and Schmalstieg.

Graduate Faculty: Associate Members Gebhard and Paternost.

Opportunities for specialization in literature or linguistics are available. A minimum requirement for admission is an undergraduate major in Russian or its equivalent.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

The department prefers that M.A. candidates in this major submit a term paper rather than a thesis.

RUSSIAN (RUS)

426. DOSTOEVSKY (3)
427. TOLSTOY (3)
430. METHODS AND MATERIALS FOR TEACHING RUSSIAN (3)
450. HISTORY OF THE RUSSIAN LANGUAGE (3)
460. LINGUISTIC ANALYSIS OF CONTEMPORARY RUSSIAN (3)
497. PROBLEMS IN RUSSIAN (3-9)

*1G. TECHNICAL RUSSIAN FOR GRADUATE STUDENTS (3) Prepares student to translate technical and scientific texts. No previous knowledge of Russian is required.

*2G. RUSSIAN TEXTS (3) Development of skill in translating Russian texts in the sciences and social sciences. Prerequisite: Rus. 5 or 1G.

501. READINGS IN RUSSIAN LITERATURE (3-6) Prerequisite: Rus. 204.

525. PUSHKIN (3) Pushkin's significance in Russian literature; his relation to other European literatures; *Eugene Onegin* and selected shorter works.

540. EIGHTEENTH-CENTURY RUSSIAN LITERATURE (3) Study of the major writers and literary developments in this period of the secularization and modernization of Russian literature.

542. SEMINAR IN SOVIET LITERATURE (3-6) Works of representative Soviet writers; individual research in contemporary Soviet literature and literary criticism.

570. OLD RUSSIAN LITERATURE (3) Analysis of Russian literary monuments in the original, 1100-1700. Prerequisite: Slav. 550.

SLAVIC (SLAV)

500. BIBLIOGRAPHY AND RESEARCH TECHNIQUES (3) Tools and methods of research, designed for students preparing to do independent investigation of problems in Slavic languages and literatures.

510. STRUCTURE OF THE SOUTH SLAVIC AND WEST SLAVIC LANGUAGES (3-12; 3 credits per language) Linguistic analysis of a particular South Slavic (Bulgarian, Macedonian, Serbo-Croatian, Slovenian) or West Slavic (Czech, Lusatian, Polish, Slovak) language. Prerequisite: Rus. 460 or one graduate course in linguistics.

550. OLD CHURCH SLAVIC (3) Reading and study of that corpus of religious and liturgical documents representing the first written records of a Slavic tongue.

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*No graduate credit is given for this course.

560. THEORY AND TECHNIQUE IN SLAVIC LINGUISTICS (3-6) Analysis of the relationship of the Slavic languages; consideration of particular linguistic problems within one or more of the languages.

SOCIAL STUDIES (SO ST)

HUGO A. MEIER, *Chairman of the Committee on Social Studies*
612 Liberal Arts Tower

Degree Conferred: M.Ed.

This program provides advanced study in history and the social sciences for secondary school teachers. Candidates select a minimum of 24 credits representing at least four of the following areas, with an emphasis of 9 to 12 credits in one of them: history, political science, sociology, economics, human geography, and rural sociology. A minor field of at least 6 credits in educational foundations is required.

For admission a student must have had solid preparation in the basic courses in economics, history, political science, and sociology and should have had some advanced undergraduate work in at least one of these areas. He must also have had 18 credits in education and related psychology, and he should be certified for teaching social studies. Ideally, he should have had teaching experience in this field as well.

Students who present a 2.50 junior-senior average and a 3.00 average in the social studies areas will be considered for admission. The best-qualified applicants will be accepted up to the number of places that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

SOCIOLOGY (SOC)

ROLAND J. PELLEGRIN, *Head of the Department*
201B Liberal Arts Tower

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members Buck, Clark, DeJong, Faulkner, Matson, Pellegrin, Simirenko, Snyder, and Theodorson.

Graduate Faculty: Associate Members Bord, Clemente, Foreman, Gelman, Humphrey, Kemple, Meahl, Raphael, Rath, Sim, and Westby.

The M.A. and Ph.D. programs center around training in basic social theory and methodology and the empirical findings in the various areas of sociology. Departmental offerings cover a wide range, including courses and seminars in most fields of specialization in the discipline. The program is designed with considerable flexibility so that students can adapt course work outside the department to their individual interests and goals. Work in computer science, philosophy of science, or mathematics may be used to fulfill part of the Ph.D. degree communication and foreign language requirement, but a reading knowledge of a minimum of one foreign language is required. All first-year students who intend to pursue doctoral work are expected to earn an M.A. degree in their normal progress to the Ph.D. The department offers three options leading to the M.A. degree. The choice of program option will be determined by agreement between the student and his adviser. A student has the option to write a thesis or a paper for the M.A. degree.

Undergraduate training in sociology is expected. Students of ability who are deficient in undergraduate preparation may be accepted with provisions to make up course deficiencies in the early part of their graduate program. Candidate selection is based on the following informa-

tion: quality undergraduate academic performance, above average Graduate Record Examination scores, letters of recommendation, an essay giving the applicant's interests, goals, and purposes for graduate work in sociology, and submission of written work from the student's undergraduate program, such as a term paper. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

The Population Issues program is a course of study focusing on the social, economic, and geographic policy-related issues arising from the dynamics of population trends, especially in developed nations. In addition to departmental admission requirements, the Population Issues Committee evaluates the student's interest and aptitude for the training program which consists of a minimum of 21 credits of interdisciplinary course work in population.

Other areas of study related to sociology, such as rural sociology, community development, cultural anthropology, developmental psychology, and political behavior, are offered in other departments of the University.

Special departmental research and training facilities include the Liberal Arts Data Laboratory, small groups research laboratory, and a sociology reference library. Additional University facilities used by sociology faculty and graduate students include the Computation Center, the Inter-University Consortium of Political Research, the Institute of Public Administration, the Institute for Research in Human Resources, and the Center for the Study of Religion and Human Resources.

SOCIOLOGY (SOC)

400. Advanced General Sociology (3)
401. Social Institutions (3)
403. Advanced Social Psychology (3)
404. Small Groups (3)
406. Sociological Analysis of Deviance (3)
408. Social Ecology (3)
410. Social Psychology of Health (3)
412. Penology (3)
413. Methods and Techniques of Social Research (3)
415. The Urban Community (3)
416. (C.F.Ed. 416) Sociology of Education (3)
418. The Development of Social Thought (3)
419. Race Relations (3)
422. History of Sociological Theory (3)
423. Social Demography (3)
424. Social Change (3)
426. Public Welfare Policy and Services (3)
427. Social Case Work (3)
428. Seminar in Sociology (1-6)
429. Social Stratification (3)
430. Family in Cross-Cultural Perspective (3)
432. Collective Behavior (3)
435. Social Gerontology (3)
436. (Journ. 436) Sociology of Opinion Formation (3)
438. (Rl.St. 438) Religion and Urban Society (3)
444. Complex Organizations (3)
446. Political Sociology (3)
447. Environmental Sociology (3)
450. Community Organization (3)
451. Comparative Analysis of American and Soviet Societies (3)
453. (Anthy. 453) Primitive Religion (3)
454. (L.S. 454) Industry and the Community (3)

455. (L.S. 455) The Sociology of Work (3)
456. Readings in Sociology (1-9)
457. (L.S. 457) Field Work in Work Organizations (1-6)
461. (R1.St. 461) Sociology of Religion (3)
470. Intermediate Social Statistics (4)
473. Methods of Demographic Analysis (3-6)
499. Foreign Study in Sociology (2-6)

500. Seminar in Group Theory (1-3) The group as a unit of social structure and action.

502. Theories of Society (3) Past and present theories of the overall structure and processes of societal functioning.

503. Research Seminar in Social Psychology (3-6) Design and conduct of research in areas of mutual interest in social psychology.

504-505. Current Social Theory (3 each) Current contributions to social theory; their relations to each other and to the larger theoretical structure.

506. Seminar in Sociological Theory (3-9)

507. Introduction to Graduate Study in Sociology (1) Required of all incoming graduate students in sociology.

509. Seminar in Medical Sociology Research (1-6) Early and current classics of medical sociology research critically reviewed; limitations and possibilities; needs of society; available resources. Prerequisites: Soc. 410, 413.

510. Field Work in Sociology (1-6)

511. Readings in the Sociology of Health (1-6) Independent pursuit of existing knowledge in fields of the student's interest, in reference books, monographs, journals. Bibliography preparation. Prerequisite: Soc. 410.

512. Seminar in Deviant Behavior (2-6) Advanced sociological study of crime, juvenile delinquency, mental disorders, suicide, drug addiction, prostitution, and other social deviation. Prerequisite: 6 credits in sociology.

513-514. Sociological Methods (3 each) Critical review of methodological issues; philosophy of science; research designs; analysis and interpretation of findings. Prerequisites: Soc. 413, 470.

515. Seminar in Community Studies (3)

518. Research Studies in the Sociology of Education (3) Analyses of the design, methods, and findings of selected classical and current research studies in the sociology of education. Prerequisite: Soc. 416.

523. Seminar in Population Theory and Policy (1-6) Critical review of multidisciplinary population research with an emphasis on its relation to policy issues. Prerequisite: 3 credits in population or human ecology.

525. Seminar in Sociology (1-6) Research problems in theoretical and applied sociology.

529. Seminar in Intergroup Relations (3) Review of research into minority-majority group relations.

530. Research on Marriage and the Family (3) Training in methods and techniques of research in family relations. Experimental, statistical, and comparative studies are carried out, individually or cooperatively. Prerequisite: 3 credits of previous work in this field.

532-533-534. Social Relations (3 each) Critical appraisal of major social-psychological problems confronting modern man; emphasis on formulation of fruitful research projects and their evaluation. Prerequisite: 15 graduate credits in social science departments or psychology, including a course in statistics.

535. Seminar in Gerontology (2-6) A structural-functional analysis of current research dealing with the relationships between institutional structure, age grading, and social behavior.

*546. Seminar in Political Sociology (3-6) Research and analysis of contemporary issues in political sociology. Prerequisite: 3 credits in statistics.

551. Comparative Institutions and Systems of Stratification (3) Critical appraisal of major problems in comparative sociology, including comparative studies of Western, socialist, and Third World countries.

555. Industrial Sociology (3) Research methods and techniques in industrial sociology; current research, unexplored areas.

572-573. Social Statistics (3 each) Application of parametric and non-parametric statistical methods to sociology; sampling; computer data processing techniques. Prerequisites: Soc. 470 and 3 credits in research methods.

574-575. Quantitative Sociology (3 each) Problems and issues in the mathematical and quantitative aspects of sociology. Prerequisites: Soc. 413, 470.

SOLID STATE SCIENCE (S S S)

Robert E. Newnham, *In Charge of Graduate Programs in Solid State Science*
169 Materials Research Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Barsch, Cross, Dachille, Henisch, Kline, Knox, McKinstry, Mulay, Newnham, D. Roy, R. Roy, Stubican, Vastola, Vedam, Walker, E. White, and W. White.

Graduate Faculty: Associate Members Fonash, Harrison, Johnson, McCarthy, and Thrower.

The aim of this intercollege program is to provide an opportunity for the student interested in the structure, properties, and behavior of solid materials to obtain an integrated program of courses encompassing both the necessary fundamentals of chemistry, physics, and mathematics and their technological and engineering applications.

The program of courses taken by a student majoring in this program must necessarily cut across two or more disciplines. The relevant subject matter has been grouped into four areas: (1) the structure of solids (crystal chemistry and structure determination); (2) theory related to the solid state (physics, chemistry, and mechanics); (3) properties of solids (optical, electrical, magnetic, mechanical, thermal, and chemical); and (4) reactions of solids (phase equilibria, reaction mechanisms, reaction kinetics, and surface reactions).

The course work of all students will normally include the "core program" as periodically redefined. Recommended course sequences for each year for students with different undergraduate backgrounds are prepared by the chairman and are available from the student's adviser. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages or by one foreign language together with courses from other designated areas.

Entering students should hold a bachelor's degree in chemistry, physics, mathematics, geological science, engineering, ceramics, or metallurgy, or in a closely related field that will have included in it mathematics at least through integral calculus and a minimum of one year of physics and one year of chemistry. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. The applicant should be interested specifically in an interdisciplinary program of study and research. Thesis research on various aspects of the solid state may be conducted in the Materials Research Laboratory, the Applied Research Laboratory, or in appropriate departments in the Colleges of Earth and Mineral Sciences, Engineering, and Science. The experimental facilities for research in several aspects of materials science and engineering are exceptional.

S.S.S. 590 (Colloquium) and S.S.S. 596 (Individual Studies) will be offered once each year to promote the interdisciplinary aspects of solid state science. Further information will be available from the Solid State Science office.

*3 credits per term.

In addition, students may select appropriate course work from any engineering or science department. The following list includes those which are most commonly taken to satisfy core curriculum requirements: Structure of Solids: Mat.Sc. 421, 512, 514. Solid State Theory: Metal. 508, 509; Phys. 410. Physical Properties of Solids: Cer.Sc. 508; Mat.Sc. 542; Phys. 412, 413, 524. Chemical Reactions in Solids: G.Chem. 513; Mat.Sc. 416.

SOLID STATE SCIENCE (S S S)

590. Colloquium (1-3)

596. Individual Studies (1-6)

SPANISH (SPAN)

MARTIN S. STABB, *Head of the Department of Spanish, Italian, and Portuguese*
N-352 Burrowes Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty: Senior Members Brentin, Dalbor, Lima, Moser, Perez, Stabb, and Sturcken.

Graduate Faculty: Associate Members Halsey, Lyday, Peavler, and Triolo.

The minimum requirement for admission will normally be 24 credits of postintermediate work in Spanish language and literature. A student may specialize in either the area of literature or descriptive and historical linguistics. The department may waive the requirement of a thesis for M.A. candidates in this major.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages or by comprehensive knowledge of one.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

SPANISH (SPAN)

400. Advanced Grammar and Composition (3)
404. The Evolution of Spanish (3)
410. Advanced Oral Expression and Communication (3)
413. The Teaching of Spanish (4)
414. Spanish Phonology (3)
415. Spanish Morphology and Syntax (3)
416. Old Spanish Literature (3)
426. The Golden Age (3)
427. Drama of the Golden Age (3)
439. Don Quijote (3)
459. The Generation of 1898 (3)
472. The Contemporary Spanish-American Novel (3)
475. Introduction to Latin-American Literature (3)
476. Introduction to Latin-American Literature (3)
477. The Literature of Mexico (3)
480. Literature of Argentina (3)
482. Spanish Lyric Poetry (3)
483. Spanish Drama of the Nineteenth Century (3)
485. Spanish Drama of the Twentieth Century (3)
487. The Spanish Novel of the Nineteenth Century (3)
489. The Spanish Novel of the Twentieth Century (3)

497. Problems in Hispanic Literature (3-12)
499. Foreign Study in Spanish (3)

502. Theory and Techniques of Teaching Spanish (1-3) Audio-lingual orientation. *Mr. Dalbor*

503. Methods and Bibliography in Spanish (1-3) Methods of research; evaluation of sources and materials. *Staff*

505. Old Spanish: Phonology, Morphology, and Syntax (3) *Mr. Sturcken*

506. History of the Spanish Language (3) *Mr. Sturcken*

507. Hispano-Romance Linguistics (3) *Mr. Sturcken*

510. Spanish Descriptive Linguistics: Phonology (3) *Mr. Dalbor*

511. Spanish Transformational-Generative Linguistics (3) *Mr. Dalbor*

514. Hispanic Dialectology (3) Early fragmentation among the peninsular dialects; origins and descriptive analysis of the American dialects; Judeo-Spanish. *Messrs. Sturcken and Dalbor*

515. Medieval Spanish Nonepic Literature (3) *Mr. Sturcken*

516. Medieval Spanish Epic Poetry and Prose (3) The *Poema de Mio Cid;* origins and diffusion of epic themes; their influence through the *crónicas,* the *Romancero,* and later literature. *Messrs. Sturcken and Triolo*

518. El Libro De Buen Amor (3) *Mr. Sturcken*

521. The Celestina and the Literature of the Spanish Pre-Renaissance (3) Chief trends and works of the period of the Catholic monarchs, with special emphasis on Fernando de Rojas' masterpiece *La Celestina. Messrs. Pérez and Triolo*

525. Spanish Renaissance and Golden Age Poetry (3) Lyric poetry, epic poetry, and balladry. *Mr. Triolo*

527. Sixteenth-Century Spanish Prose (3) The major prose writers of the Spanish sixteenth century. *Messrs. Brentin and Pérez*

528. Seventeenth-Century Spanish Prose (3) Various types of novels of the seventeenth century, with special emphasis on the picaresque, didactic literature, histories. *Messrs. Brentin and Pérez*

538. Theatre of Lope de Vega and His Cycle (3) Major works of Lope de Vega, Tirso de Molina, Buillen de Castro, Mira de Amescua, and others. *Mr. Pérez*

539. Theatre of Calderón de la Barca and His Cycle (3) Major works of Calderón de la Barca, Rojas Zorrilla, Augustin Moreto, and others. *Mr. Pérez*

540. Cervantes: The Quijote (3) A careful reading of Cervantes' famous novel and consideration of some of the corpus of criticism on the novel. *Messrs. Brentin and Pérez*

541. Cervantes: Other Works (3) Cervantes' major works, excluding the *Quijote. Messrs. Brentin and Pérez*

544. Spanish Romanticism (3) The major authors and works of peninsular romanticism, including poetry, drama and prose. *Miss Halsey and Mr. Lima*

550. Spanish Realism (3) The major figures of the period with special emphasis on Pérez Galdós. *Mr. Zamora*

554. Generation of 1898: Prose (3) Selected essays and novels from the works of Ganivet, Pidal, Unamuno, Maeztu, Azorin, Lanza, Baroja and Valle-Inclán. *Messrs. Lima and Zamora*

555. Generation of 1898: Poetry and Drama (3) Selected poems and plays from the works of Antonio and Manuel Machado, Benavente, Grau, Azorin, Valle-Inclán, Unamuno, Baroja and others. *Mr. Lima*

560. The Contemporary Novel in Spain (3) The novel since 1941: Cela, Laforet, Zunzunegui, Suárez Carreño, Matute, and others. *Messrs. Brentin and Zamora*

563. Contemporary Drama in Spain (3) The drama since 1898 to the present day: Benavente, Valle-Inclán, Garcia Lorca, Casona, Buero Vallejo, Sastre, and others. *Miss Halsey and Mr. Lima*

566. Contemporary Spanish Poetry (3) Various currents in Spanish poetry from the Generation of 1927: Lorca, Aleixandre, Salinas, Guillen, Alonso, Alberti, Hernandez, Otero and others. *Mr. Brentin*

570. Modernismo (3) The movement, its antecedents, and its followers, with special emphasis on Rubén Darío. *Mr. Moser*

572. Spanish-American Novel of the Nineteenth and Early Twentieth Century (3) Evolution of the genre and representative works. *Messrs. Lyday, Peavler, and Stabb*

573. The Contemporary Spanish-American Novel (3) Evolution of the genre since 1940 and representative novelists. *Messrs. Peavler and Stabb*

575. The Spanish-American Essay (3) Tracing the history of ideas in Spanish America through major essayists. *Messrs. Moser and Stabb*

576. Twentieth-Century Spanish-American Poetry (3) Influential poets and literary movements after *Modernismo*. *Messrs. Lyday and Stabb*

577. Spanish-American Drama (3) Dramatic literature in Spanish America from colonial times to the present. *Mr. Lyday*

579. Colonial Literature (3) Transplantation of European culture to Spanish America, literary genres cultivated in the colonies, and principal writers. *Mr. Moser*

581. The Spanish-American Short Story (3) Critical analysis of the major writers and movements from Echeverría to the present. *Messrs. Lyday, Peavler, and Stabb.*

584. Spanish-American Romanticism (3) The principal writers and tendencies of the Romantic movement in Spanish America. *Mr. Moser*

587. Stylistic and Literary Criticism (3) Major theories of literary criticism applied to Hispanic literature. *Staff*

588. Seminar in Hispanic Literature (3-12) Common and individual research in special problems in Spanish or Spanish-American literature. *Staff*

SPEECH COMMUNICATION (SPCOM)

Herman Cohen, *Head of the Department*
212 Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.A.

Graduate Faculty: Senior Members Arnold, Borden, Brubaker, Cohen, Fife, Frandsen, Gregg, Hager, Holtzman, Nelson, Paulson, Phillips, and White.

Graduate Faculty: Associate Members Barton, Benson, Butt, De Boer, Dunham, Gilbert, Hauser, Johnson, Pedersen, Preston, and Wigley.

The student may specialize in speech arts (interpretation, drama, theatre); radio and television; rhetoric and public address (including discussion, communication, teaching of speech); speech science (voice, diction, phonetics, general semantics); and communicative theory. A thesis is required of all M.A. candidates in this major.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign languages.

The minimum undergraduate preparation required is 12 credits in speech. Students who cannot meet this requirement in full may be admitted but must make up their deficiencies

without credit toward the graduate degree. Spch. 400 and 502 are required of all graduate students who do not have their equivalents.

Students with a 3.00 junior-senior average, with scores on the Graduate Record Examination (general), and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

SPEECH (SPCH)

400. Teaching of Speech (3) *Mr. Butt*
402. Speech and Human Behavior (3) *Mr. Phillips*
403. Interpersonal Oral Communication Theory (3)
410. English Phonetics and Pronunciation (3) *Mr. Brubaker*
412. Speech Criticism (3) *Mr. Arnold*
413. (Ling. 413) Experimental Linguistics (3)
417. Directing Forensics (3) *Mrs. Lutz*
419. (Journ. 419) Comparative Broadcasting Systems (3)
420. History of Rhetorics (3)
425. Radio Programming and Performance (3) *Miss Preston*
431. Anatomy and Physiology of the Ear and Vocal Mechanisms (3) *Mr. Gilbert*
435. Radio and Television Programming (3) *Mr. Nelson*
437. Television Programming and Performance (3) *Staff*
440. Speech-Communication: Research and Theory (3) *Mr. Frandsen*
450. Discussion: Research and Theory (2-6) *Mr. Phillips*
470. Nonverbal Communication (3-6) *Messrs. Benson and Frandsen*
475. Studies in Mass Persuasion in the Democratic Society (3) *Messrs. Hager and McCormack*
478. Contemporary Public Address: English and American Speakers (2) *Mr. Gregg*
480. Computer Applications in Speech Studies (3) *Mr. Borden*
485. Advanced Oral Interpretation of Literature (3) *Mr. Wigley*
489. Directed Study (1-6) *Staff*
490. Psychology of Speaking and Listening (3) *Mr. Holtzman*
494. Teaching of English as a Second Language (3) *Mr. Holtzman*
496. Speech for Teachers (3) *Mr. Butt*

500. Seminar in American Oratory (2-6) History of American oratory with application of critical standards to the work of specific orators. *Mr. White*

502. Research Methods in Speech (3) Research design, thesis proposals, and background for research in graduate study. Prerequisite: 6 credits at the 400 or 500 level in speech, clinical speech, or theatre arts. *Staff*

505. Historical Development of Speech Theory and Criticism (2-4) Classical theories of speech making from the earliest beginnings to the fall of the Roman Empire. *Mr. Arnold*

506. Historical Development of Speech Theory and Criticism (2-4) Theories of speech making from the Renaissance to the present. *Mr. Arnold*

507. Contemporary Rhetorical Theory (2-4) A study of rhetorical theory from 1930 to the present, focusing on semantic, political, sociological, symbolic, and philosophical perspectives. Prerequisites: Spch. 412, 505 and/or 506. *Mr. Gregg*

508. Seminar in British Oratory (2-4) History of British oratory; application of critical standards to the work of selected orators. *Miss Fife*

509. Problems in Rhetoric and Oratory (2-6) Comparative study of selected orators and rhetoricians. Prerequisite: 6 credits in speech. *Staff*

510. PROBLEMS IN SPEECH EDUCATION (2-4) Advanced knowledge, theories, and principles, together with their philosophical, scientific, clinical, artistic, and educational implications for the teacher of speech. Prerequisites: Spch. 502 and 9 additional credits at the 400 or 500 level in speech, clinical speech, or theatre arts. *Mr. Phillips*

520. SEMINAR IN SPEECH SCIENCE (3-6) Seminar in physical and physiological bases of speech and voice; introduction to laboratory techniques used in speech research. Prerequisite: 9 credits in speech, speech pathology and audiology, or psychology. *Messrs. Brubaker and Gilbert*

530. POLITICAL SPEAKING IN THE BROADCAST MEDIA (3) Study and research of the principles of speaking as they are employed for political purposes when utilizing the broadcast media. *Mr. Nelson*

540. SEMINAR IN PROBLEMS OF TELEVISION AND RADIO (2-4) Study and research in television and radio as they pertain to programming, production, relation to society, and speech. *Mr. Nelson*

550. SEMINAR IN ORAL PERSUASION (2-4) Theory and devices of persuasion; analysis of persuasive discourse. Prerequisite: 6 credits in speech including Spch. 200. *Messrs. Frandsen and Holtzman*

552. ORAL COMMUNICATION IN INDUSTRY, BUSINESS, AND GOVERNMENT (2-4) Needs, practices, and methods in American industry, business, and government; methods of training adults in oral communications skills. *Mr. Frandsen*

554. SEMINAR IN SMALL GROUP COMMUNICATION (2-4) Communication variables in small groups. Experimental research and innovations in communication in vocational, therapeutic, and educational groups. *Mr. Phillips*

555. SPEECH COMMUNICATION: PROBLEMS AND PRINCIPLES (2-6) Prevalent theories of speech influence. *Messrs. Borden, Frandsen, and Phillips*

575. RESEARCH PROBLEMS IN SPEECH (1-9) Advanced research on an individual basis in oratorical criticism, discussion techniques, persuasion, pedagogy, phonetics, speech science, and speech pathology. Prerequisite: 12 credits in speech or speech pathology and audiology. *Staff*

SPEECH PATHOLOGY AND AUDIOLOGY (S P A)

BRUCE M. SIEGENTHALER, *In Charge of Graduate Programs in Speech Pathology and Audiology*
110 Moore Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Frick, McDonald, Michael, and Siegenthaler.

Graduate Faculty: Associate Members Clouser, Gilbert, and Quick.

Students may specialize in speech pathology, audiology, or education of the hearing impaired. The programs include the requirement of a number of field trips to diagnostic and treatment facilities and may include a period of internship at an off-campus location. Students should expect to have moderate expenses related to these trips.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including but not restricted to foreign languages. The nonthesis option is available for the M.S. degree.

Approximately 40 credits are required, distributed among speech pathology, audiology, education of the hearing impaired, speech science, education and psychology, and including a course in statistics. Students entering without an undergraduate program in the field may be required to take additional make-up work. The admission application for each student is reviewed, and he is advised regarding admission requirements.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

SPEECH PATHOLOGY AND AUDIOLOGY (S P A)

430. Introduction to Audiology (3)
433. Visual Speech Reception and Auditory Training (3)
434. Pure Tone Audiometry (3)
439. Practicum in Auditory Training and Speech Reading (1-5)
440. (E.E.C. 440) Survey of Speech and Hearing Disorders (3)
441. Current Problems in Speech Pathology and Audiology (1-6)
442. Speech Pathology: Articulation and Stuttering (3)
444. Speech Pathology: Voice and Organic Disorders (3)
445. Professional Programs and Relationships (3)
449. Practicum in Speech Therapy (1-6)
459. Principles of Clinical Management in S.P.A. (2)
460. Communication Skills for Hearing Impaired I (2)
461. Communication Skills for Hearing Impaired II (3)
462. Clinical Bases of Language Disorders (2)
463. Teaching Language to the Hearing Impaired (3)
464-465. Teaching Elementary School Subjects to the Deaf (2 each)
467. Audiology for Teachers of the Deaf (3)
469. Student Teaching with the Deaf (3-12)

515. Application of Physiological and Acoustical Concepts of Speech Pathology and Audiology (4) Application of practical and theoretical concepts in neurology, physiology, and acoustics to communication disorders with implications for clinical therapy. Prerequisites: 6 credits in speech science and 6 credits in speech pathology and audiology.

516. Applications of Psychology of Speech to Speech Pathology and Audiology (1) Application of psychological concepts germane to theoretical and practical understanding of communication disorders; implications for clinical speech and language therapy. Prerequisites: 6 credits in speech pathology and audiology and 6 credits in psychology.

530. Seminar in Audiology (1-6) Review of theories of hearing and review of related physiological and psychological researches. Prerequisite: S.P.A. 434.

531. Speech Audiometry and Hearing Aids (3) Techniques and interpretation of speech reception tests; hearing aids and hearing aid advisement procedures; observations and practice in test administration. Prerequisite: S.P.A. 434.

532. Acoustical Instruments for Hearing (3) Acoustical instrumentation used for research in hearing, programs of hearing conservation, and noise control, including clinical and industrial applications. Prerequisite: 6 credits in acoustics, audiology, experimental psychology, or speech science at 400 level.

534. Noise and Hearing (3) Noise-induced hearing problems; interference with communication; annoyance and community problems caused by acoustic energy; regulations and standards. Prerequisite: 6 credits at 400 level in acoustics, audiology, experimental psychology, or speech science.

538. Practicum in Audiologic Evaluation and Selection of Hearing Aids (1-5) Prerequisite: S.P.A. 531.

539. Advanced Practicum in Education of the Deaf (1-6) Theoretical and clinical rationale of working with hearing impaired, professional role and relationships, therapy procedures, evaluation of process and outcomes. Prerequisite: S.P.A. 439.

540. Articulation Disabilities (3) Speech-sound production disorders in children and adults; methods of examination, diagnosis, and treatment. Prerequisites: S.P.A. 442, 449.

541. The Voice and Its Disorders (3) Physical, physiological, and psychological bases of voice production; causes, nature, and symptoms of its disorders; current clinical methods in voice improvement. Prerequisites: S.P.A. 444, 449.

542. Stuttering (3) Modern theories of causes of disorders of rhythm; methods of examination, diagnosis, and treatment. Prerequisites: S.P.A. 442, 449.

543. Diagnostic Procedures in Clinical Speech (3) Clinical instrumentation; case history taking; examination procedures and materials used in diagnosing speech disabilities; interpretation of findings; report preparation. Prerequisite: S.P.A. 444.

544. Cleft Palate (3) Anatomy, physiology, embryology, and growth of the palate and contiguous structures; etiology, diagnosis, habilitation of cleft palate problems. Prerequisite: S.P.A. 444.

545. (E.E.C. 545) Cerebral Palsy (3) Etiology and symptomatology of cerebral palsies; diagnosis and treatment of communication problems; the multiprofessional habilitative program. Prerequisite: S.P.A. 444.

546. Language Disorders in Adults (3) Nature, etiology, diagnosis, and management of language disorders in adults. Prerequisite: 9 credits in speech pathology and audiology or related fields such as psychology, linguistics, or human development.

547. (E.E.C. 547) Language Disorders in Children (2) Nature, etiology, diagnosis, and management of language disorders in children. Prerequisite: 9 credits in speech pathology and audiology or related fields such as psychology, linguistics, or human development.

548. Practicum in Speech Diagnosis (1-3) Supervised practice in interviewing, counseling, speech evaluation, and synthesis of psychological, medical, and audiological data in speech diagnosis; report writing. Prerequisites: S.P.A. 444, 449.

549. Advanced Practicum in Speech Therapy (1-6) Theoretical and clinical rationale of therapy; professional role and relationships; therapy procedures, individual and group; evaluation of process and outcomes. Prerequisites: S.P.A. 442, 449.

550. Seminar in Speech Pathology (1-6) Advanced study of special problems and new developments in speech pathology. Prerequisites: S.P.A. 442, 444.

560. Recent Developments in Education of the Deaf (2-6) In-depth seminar-style study of communication disorders associated with deafness, and advanced and experimental attempts at remediation. Prerequisites: 8 credits in education of the deaf or audiology, S.P.A. 430 and 433, and 3 credits in child development or learning theory.

566. Education and Guidance of the Hearing Impaired (3) Effects of hearing impairment on developmental, educational, social, and vocational adjustment; assisting the hearing impaired toward improved life adjustment. Prerequisites: S.P.A. 430, 433.

596. Individual Studies (1-6)

STATISTICS (STAT)

William L. Harkness, *Head of the Department*
333 McAllister Building

Degrees Conferred: Ph.D., M.S., M.A.

Graduate Faculty: Senior Members Antle, Bartoo, Haight, Harkness, Hultquist, Joiner, and Patil.

Graduate Faculty: Associate Members Boswell, Hettmansperger, Kappenman, Klimko, and Ryan.

Graduate instruction and research opportunities are available in most areas of probability and statistics, including experimental design, linear models, multivariate analysis, nonparametric statistics, analysis of counted data, computerized data analysis, distribution theory, stochastic processes (applied and theoretical), various areas in probability theory, and statistical ecology.

The opportunity is also available for students to gain practical experience by participating, for academic credit, in the department's consulting and collaborative research program.

For the M.A. degree the candidate must complete 30 course credits, with at least 18 credits (12 in statistics) of 500-level courses, 3 credits in computer science, Math. 441 or 481, 3 credits in seminars and/or individual studies, and six courses in an approved area. The degree requirements for the M.S. degree are the same as for the M.A., except 6-9 credits of thesis replace an equal number of course credits.

The department administers a master's and Ph.D. qualifying examination which all students in the program must take. Students are examined in two areas of their choice from mathematical statistics, applied statistics, and probability. This examination is intended to be taken early in the program and Ph.D. candidacy is contingent on successful completion of the exam.

The communication and foreign language requirement for the Ph.D. degree is flexible, requiring none, one, or two foreign languages, depending on the individual's program; if less than two languages are allowed, appropriate substitutions involving interdisciplinary work that leads to the development of a strong area of application and/or computer science may be required. Emphasis is placed on helping the student expand his creative ability to solve real problems having statistical aspects.

While applications from all students (including those who already have done graduate work) are reviewed, completion of a standard calculus sequence is regarded as a prerequisite. Students with a 3.00 or better junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

The department requires the verbal and quantitative scores on the Graduate Record Examination from those applicants who wish to be considered for financial support. All applicants for admission are encouraged to submit the GRE scores.

Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees (see p. 230).

STATISTICS (STAT)

401. Experimental Methods I (3)
402. Experimental Methods II (3)
409-410. (Math. 409-410) Introduction to Mathematical Statistics (3 each)
412. (Math. 412) Introduction to Mathematical Statistics (3)
418. (A.M. 418, Math. 418) Discrete Probability Theory (3)
427. (Math. 427) Discrete Stochastic Models (3)
451. Introduction to Applied Statistics (3)
461. Sampling Methods (3)
462. Applied Regression Analysis (3)
464. Applied Nonparametric Statistics (3)
490. Special Topics in Probability and Statistics (3-9)

501. Data Analysis and Regression (3) Use of simple and multiple regression and correlation to analyze research data; dummy variables, step-wise and non-linear regression. Prerequisite: 3 credits in statistics. Prerequisite or concurrent: matrix algebra.

502. Analysis of Variance and Design of Experiments (3) Experimental design and analysis; fixed, mixed and random effects models; covariance analysis; multiple comparisons; repeated measures; unbalanced data; computer techniques. Prerequisite: 6 credits in statistics.

503. Analysis of Experimental Data (3) Statistical analysis and interpretation of data. Intended for students who have (or will have) data to analyze. Prerequisites: Stat. 462 or 501; Stat. 502.

504. Analysis of Categorical Data (Contingency Tables) (3) Classical analysis of multi-factor contingency tables; linear and log-linear models; measures of association; graphical methods. Prerequisites: 6 credits in statistics, matrix algebra.

505. Applied Multivariate Statistical Analysis (3) Analysis of multivariate data; T^2-tests; partial correlation; discrimination; MANOVA; cluster analysis; regression; growth curves; factor analysis; principal components; canonical correlations. Prerequisite: 6 credits in statistics.

506. Sampling Theory (3) Theory and application of sampling from finite populations. Prerequisite: 6 credits in statistics.

507. Sequential Analysis (3) A thorough discussion of sequential procedures of estimation and testing of hypotheses. Prerequisite: Stat. 410.

508. Characterization of Statistical Models (3) Characteristics of different statistical distributions; characterizations of distributions through structural properties and statistical procedures. Prerequisite: Stat. 543.

509. Discrete Statistical Models and Methods (3) Systematic study of probability models and statistical methods pertaining to statistical analysis of data consisting of single and multiple counts. Prerequisite: Stat. 554.

512-513. (A.M. 512-513) Introduction to Stochastic Processes (3 each) Markov chains, random walk and recurrent events, queuing theory, time-dependent stochastic processes. Prerequisite: Stat. 418.

517-518. (Math. 517-518) Probability Theory (3 each) Measure theoretic foundation of probability, distribution functions and laws, types of convergence, central limit problem, conditional probability, special topics. Prerequisites: Math. 452, 501.

524. Ecometrics (3) Stochastic models and statistical methods in ecological problems; population dynamics, spatial patterns in populations of one, two or more species. Prerequisite: Stat. 409 or 418.

528. Queuing Models in Transportation (3) Arrival patterns, the service mechanism, queue discipline, delays, multiple queues, problems involving interrupted flow, multiflow routes.

534. (M.E.R. 534) Dynamic Programming (3) The study of the concepts underlying model-building and optimization of dynamic systems; applications to engineering, economic and environmental systems. Prerequisites: Stat. 418; I.E. 405 or Q.B.A. 451.

542-543. (Math. 542-543) Statistical Distribution Theory (3 each) Random variables and expectations; discrete, continuous, univariate, multivariate, exact, and asymptotic distribution theory. Prerequisites: Math. 421; Math. 441 or 481.

551. Linear Models I (3) Statistical distribution theory of quadratic forms and linear transformations; full-rank estimation; regression; response surfaces; Cochran's theorem. Prerequisites: Stat. 502; Math. 441 or 481.

552. Linear Models II (3) Non-full rank statistical inference, interaction, variance components, covariance analysis, cross, hierarchal and incomplete classification theory and methodology. Prerequisite: Stat. 551.

558-559. (Math. 558-559) Theory of Stochastic Processes (3 each) Stationary, independent, and orthogonal processes, discrete and continuous Markov processes, martingales and semi-martingales applications. Prerequisite: Stat. 518 (Math. 518).

561. Statistical Inference I (3) Multiparameter estimation; linear estimation; maximum likelihood estimation; Bayesian estimation; large sample properties and procedures. Prerequisite: Stat. 410.

562. Statistical Inference II (3) Testing statistical composite hypotheses; invariance principles; Bayesian statistics; large sample properties and procedures. Prerequisite: Stat. 561.

564. Nonparametric Statistics: Theory (3) Estimation and testing based on nonparametric procedures for location and regression models. Distribution theory and asymptotic efficiency. Prerequisites: Stat. 410 and 3 additional credits in statistics.

565. Theory of Multivariate Statistical Analysis (3) Multivariate normal, Wishart and related distribution; Hotelling's T^2 and Cochran's theorem; classification; growth curves; cluster analysis; factor analysis. Prerequisite or concurrent: Stat. 505. Prerequisites: Stat. 410; Math. 441 or 481.

572. Statistical Decision Theory I (3) Structure of statistical games; optimal strategies, fixed sample-size games. Prerequisite: Stat. 410.

573. Statistical Decision Theory II (3) Sufficient statistics; the invariance principle; estimation and testing. Prerequisite: Stat. 572.

590. Colloquium (1-3)

591. Seminar in Probability Theory (1-6) Lectures on current and recent research in various special topics in probability theory.

596. Individual Studies (1-6)

597. Special Topics (1-6)

THEATRE ARTS (THEA)

Douglas N. Cook, *Head of the Department of Theatre and Film*
103 Visual Arts Building

Degrees Conferred: M.A., M.F.A.

Graduate Faculty: Senior Members Manfull, Smith, Walters, and Yeaton.

Graduate Faculty: Associate Members Allison and Cook.

This program emphasizes the study of the theatre with the following major objectives: (1) to help each graduate student attain skills and proficiencies in theatre arts; (2) to provide the training, discipline, and opportunities essential to the development of a professional ability in at least one area of the arts of the theatre; (3) to prepare students for active careers in academic, professional, and/or community theatre in a recognizably competitive job market; and (4) to assist students in acquiring discriminating taste and critical judgment in drama and theatre.

The M.A. program is planned to provide breadth of studies in theatre. A thesis in some area of specialization is required. The program requires approximately 4-6 terms to complete.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Requirements for admission to the M.A. program are:

1. A broad undergraduate preparation in theatre, including courses in basic acting, directing, theatre crafts, and theatre history (or their equivalents as indicated by evidence of practical experience in the theatre).

2. Eighteen credits in related subject areas, such as oral interpretation, dramatic literature, music, and art.

The M.F.A. program is planned to provide a professional emphasis. Specialization in the following areas is stressed: performance (acting or directing); production (scene design, costuming, lighting, or technical direction); or playwriting. A required final project in the area of specialization includes a monograph. The program requires approximately 9 terms to complete.

Requirements for admission to the M.F.A. program are:

1. Twenty-four credits in theatre arts, including one course each in acting, directing, and theatre crafts. Related courses in the student's area of specialization may be accepted.

2. All students are to submit evidence of ability in their areas of specialization under arrangements to be made with the department. Auditions, prompt books, portfolios, manu-

scripts, and other appropriate presentations are to be submitted by applicants to the various study programs.

3. Vitae and letters of recommendation (at least three) are to be submitted.
4. Personal interviews should be arranged by all students.

All students in the M.A. and M.F.A. programs who are deficient in the required undergraduate courses may be requested to take additional course work in the areas of deficiency without degree credit.

Under certain circumstances the Ph.D. degree is offered by the Department of English with specialization in drama and minor work in theatre arts.

All graduate majors are required to participate in University Theatre productions in positions of responsibility.

Theatre facilities are: the Playhouse, a proscenium-thrust theatre; the Pavilion, an arena or three-quarter theatre; theatre production studios for scenic, property, and costume preparation; rehearsal and dance studios, and a film laboratory with screening and editing facilities. Other University performance facilities include Schwab Auditorium, Kern Assembly Room, Music Concert Hall, and the new 2,500-seat University Auditorium. On the campus are several FM radio stations and WPSX, the University's educational TV station.

Related courses offered by other departments may be taken. Dramatic literature courses are available: Class. 411; C.Lit. 486, 487, 588; Engl. 438, 444, 448, 458, 478, 488, 548, 549; Fr. 446, 461, 518, 534, 535, 567; Greek 421, 422; Latin 426. Design and technical courses are available in the Departments of Art, Art History, Engineering, Art Education, Architecture, Human Development, and Vocational Industrial Education. Courses in performance areas are available in the Departments of Music, Music Education, Physical Education, and Speech Communication.

THEATRE ARTS (THEA)

401. History of Ancient and Medieval Theatre (3)
402. History of Renaissance and Oriental Theatre (3)
403. History of Modern European and British Theatre (3)
405. History of American Theatre (3)
410. Creative Dramatics with Children (3)
411. Projects in Creative Dramatics (2)
416. Children's Theatre (3)
417. Staging Theatre for Children (3)
418. Marionettes and Puppetry (3)
424. Dance for the Theatre (3)
425. Dance for the Contemporary Musical Theatre (2-6)
427. Theatre Makeup (2)
429. Theatre Performance Practicum (1-6)
434. Directing (3)
435. Rehearsal Methods for the Director (3)
436. Central Staging (3)
445. Advanced Playwriting (3-6)
450. Advanced Scene Design (3-6)
460. Costume Design (3)
461. Costume Construction (3)
462. Drafting Historical Costumes for the Stage (3)
474. Stage Lighting (3)
479. Stage and Production Management (3)
485. Sound for Theatre Production (3)
489. Theatre Production Practicum (1-3)
490. Motion Picture Techniques (3-6)
491. Film Authors I (3)
492. Film Authors II (3)
493. Film Authors III (3)
495. Performance for the Camera (3)

496. Radio and Television Directing (3)

500. Theatre Research: Sources and Procedure (1) Materials and techniques as applied to theatre research; the form and content of theses and monographs.

503. Theatre Criticism and Theory (3)

505. Theatre History (3) Specific aspects of theatre from ancient times to the present.

522. Acting I (4) Interpretation of theatrical styles: the tradition of tragedy; voice and movement.

523. Acting II (4) Interpretation of theatrical styles: the tradition of comedy; voice and movement. Prerequisite: Thea. 522.

524. Acting III (4) Interpretation of theatrical styles: forms of modern realism; voice and movement. Prerequisite: Thea. 523.

525. Acting and Directing Theory (3) The actor and director as related to cultural environment from the Greek theatre through the post-Stanislavskian theorists.

528. Advanced Acting Projects (3-9) Advanced performance projects for the second- and third-year M.F.A. actor who has completed all other performance courses.

530. Play Interpretation for the Director (3) Theory and practice in the analysis and implementation of story, style, and form.

531. Special Forms in Directing (3) Applied theory and techniques for various genres and periods of drama. Prerequisite: Thea. 530.

533. Projects in Directing (1-6 per term)

535. Experimental Theatre (1-3) Operational research and experimental methods in the preparation, planning, execution, observation, and evaluation of production.

540. Playwriting (3-6) Focus on problems in writing the full-length script through seminar, play reading, and individual session.

543. Projects in Playwriting (1-9) Preparation of the script for revision during and rewriting following production of the student's original play. Prerequisite: production approval.

553. Design and Technical Production (1-6 per term) Special projects in design and technical execution of scenery, costumes, lighting, sound, and special effects.

560. Costume Design (1-6) Design concepts, rendering, and execution of costumes for the stage.

574. Lighting for Theatre Production (3) Design techniques for production in arena, thrust, and proscenium theatre situations.

580. Theatre Technology (3) Design consultation and specification of equipment, systems, and movable structures for new theatres; structures and projection devices for production.

582. Theatre Administration (3) The theatre: organization and management.

583. Projects in Theatre Administration, Management, and Operations (1-6)

585. Theatre Planning (3) Processes and problems in planning and designing theatres: performance, audience, and technical requirements.

590. Colloquium (1-3)

591. Special Problems in Film and TV (1-3 per term)

596. Individual Studies (1-6)

597. Special Topics (1-6)

VETERINARY SCIENCE (V SC)

ALFRED L. BORTREE, *Head of the Department*
115D Animal Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Bortree, Dunne, Gentry, Glantz, and Rothenbacher.

Graduate Faculty: Associate Members Eberhart, Kradel, Scholz, Swope, and Zarkower.

Areas of specialization include veterinary pathology, veterinary physiology, and veterinary microbiology. There is opportunity for cooperative research with other departments in animal science, microbiology, and physiology. Unless excused by specific departmental action, all doctoral candidates must attain the master's degree as a step toward candidacy for the Ph.D. degree. A thesis is required of all candidates for the M.S. degree.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by proficiency in reading one foreign language. In the case of foreign students whose native language is other than English, this requirement may be waived with the approval of the doctoral committee.

Prerequisites for admission are a veterinary degree or a bachelor's degree in a related biological field. Adequate preparation in the basic sciences compatible with the candidate's objectives is required. Students may be admitted with limited deficiencies and are required to remove undergraduate deficiencies without degree credit.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. Academic records of candidates with the Doctor of Veterinary Medicine degree or M.S. degree will be reviewed and acted on by the graduate faculty of the department.

VETERINARY SCIENCE (V SC)

401. ECOLOGY OF ANIMAL DISEASE (3) *Mr. Kradel*
405. LABORATORY ANIMAL SCIENCE (3) *Mr. Ferguson*
418. METHODS OF ANIMAL CELL CULTURE (3) *Mr. Patton*
420. GENERAL ANIMAL PATHOLOGY (3) *Mr. Dunne*

525. MECHANISMS OF HYPERSENSITIVITY AND IMMUNOPATHOLOGY (3) Concepts of hypersensitivity and special consideration of immunopathological conditions. Prerequisites: Biol. 437, Micrb. 410, and 3 credits of pathology. *Mr. Zarkower*

528. DIAGNOSTIC PATHOLOGY (3-9) Gross examination of animals and birds, their tissues and body fluids for pathologic changes. Prerequisites: 6 credits in pathology, microbiology, or infectious diseases.

535. ACQUIRED AND CONGENITAL DISORDERS OF METABOLISM (3) Abnormalities and alterations in metabolism due to dysfunctions of animal organs. Prerequisites: 6 credits in general biochemistry and 3 credits in animal physiology. *Mr. Scholz*

581. SEMINAR IN VETERINARY SCIENCE (1-4) Presentation and critical discussion of results of personal research or topics of current interest.

582. SPECIAL PROBLEMS (1-9) Investigation of special disease problems, including laboratory and field studies.

VOCATIONAL INDUSTRIAL EDUCATION (VI ED)

ANGELO C. GILLIE, SR., *In Charge of Graduate Programs in Vocational Industrial Education*
254 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members Brandon, Brantner, and Gillie.

Graduate Faculty: Associate Members Kapes, Long, and Welch.

Emphasis may be placed upon preparation for teaching, supervision, administration, research, or teacher education. The primary focus of the program is preparation for entry into responsible positions within the broadly conceived field of vocational education.

The communication and foreign language requirement for the Ph.D. degree may be met by the successful completion of selected courses in statistics and computer programming.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

INDUSTRIAL EDUCATION (I ED)

402v. SUPERVISION OF VOCATIONAL EDUCATION (3)
403v. SUPERVISED FIELD WORK (6)
408v. OCCUPATIONS (3)
409v. TESTS AND MEASUREMENTS (3)
412v. SPECIAL PROBLEMS IN VOCATIONAL EDUCATION (6)
415v. PROBLEMS IN COORDINATING VOCATIONAL EDUCATION (3)
420v. OCCUPATIONAL HYGIENE (3)
427v. ADVANCED COURSE OF STUDY BUILDING (3)
446v. IMPROVEMENT OF INSTRUCTION IN VOCATIONAL EDUCATION (4)
450v. SHOP LAYOUT AND MANAGEMENT (3)

501v. SEMINAR IN VOCATIONAL EDUCATION (6) Conferences, investigations, and discussion for advanced students and mature persons who have had experience as teachers, supervisors, or administrators.

506v. ADMINISTRATION OF VOCATIONAL EDUCATION (3) The job of the local director of industrial education in organizing and developing city and other local programs of industrial education. Prerequisite: 6 credits in industrial education, valid director's certificate, or equivalent training and experience.

510v. VOCATIONAL EDUCATION FOR ADMINISTRATORS (3) Designed for school administrators and supervisors who desire an understanding of practical arts and vocational education. Prerequisite: I.Ed. 1v or trade or teaching experience.

550v. RESEARCH IN VOCATIONAL EDUCATION (3) Research techniques in vocational industrial education.

556v. FEDERAL LEGISLATION (2-3) Recent federal legislative activities and executive orders that bear directly and indirectly upon industrial education.

557v. PRESENT-DAY LOCAL, PERSONNEL, AND CURRICULUM PROBLEMS (2-3) Various plans, techniques, and practices.

558v. STATE AND LOCAL SUPERVISION AND ADMINISTRATION (2-3) The more important recent problems in organization, supervision, and administration.

559v. VOCATIONAL TECHNICAL EDUCATION (2-3) Problems of organization and administration of programs of technical education at the secondary and post-secondary levels. Prerequisite: 6 credits in industrial education, valid director's certificate, or equivalent training and experience.

560v. PHILOSOPHY OF INDUSTRIAL EDUCATION (3) Principles and beliefs of progressive industrial education; literature for evaluating instructional practices. Prerequisite: 12 credits in industrial education or teaching experience.

WILDLIFE MANAGEMENT (W L M)

WILBER W. WARD, *Director of the School of Forest Resources*
101 Ferguson Building

Degree Conferred: M.S.

Graduate Faculty: Senior Members Fletcher, George, Hutnik, Lindzey, and Ward.

Graduate Faculty: Associate Members Anthony, Storm, and Wood.

Programs are designed to give students an understanding of the biology and management of wildlife species and their environments, and include training in: wildlife ecology, nutrition, physiology, behavior, and pathology of a wildlife species or species groups; study of successional stages, land use, and management of various habitats and their impact on wildlife populations; population dynamics and manipulation of animal numbers; and studies of recreational, aesthetic, and socioeconomic values of wildlife. Most programs of study are strengthened by including appropriate courses offered by related departments. A thesis is required. The Ph.D. degree in forest resources allows specialization in wildlife ecology and management at the doctoral level (see Forest Resources).

Applicants should present a minimum of 12 credits in calculus, statistics, and computer science; 12 credits in chemistry and physics; 12 credits in communications; 12 credits of economics and social sciences or humanities; and 27 credits in biological sciences including courses in forestry or wildlife. Each applicant should arrange for three reference report forms to be sent and should submit a brief statement describing his academic goals, career interests, and special qualifications for proposed studies. Students with a 2.50 grade-point average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces available. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

WILDLIFE (WILDL)

408. MAMMALOGY (3)
446. WILDLIFE ECOLOGY (3)
447. WILDLIFE MANAGEMENT (3)
492. FIELD RESEARCH TECHNIQUES (3)
493. LABORATORY TECHNIQUES IN WILDLIFE RESEARCH (3)
497. PROBLEMS IN WILDLIFE (1-3)

547. WILDLIFE MANAGEMENT (3) Management, maintenance, and manipulation of wildlife populations and habitat. Prerequisite: Wildl. 447.

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-6)

597. SPECIAL TOPICS (1-6)

ZOOLOGY (ZOOL)

JOSEPH G. O'MARA, *Head of the Department of Biology*
208 Life Sciences I Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members Anthony, Bellis, Butler, Cooper, Dalton, Dunson, Gaffney, Hale, Hibbard, Hymer, MacCluer, Wickersham, and Williams.

Graduate Faculty: Associate Members Abplanalp, Arnold, Hollis, Mitchell, and Neff.

This program offers emphasis in animal behavior, cell biology, developmental biology, ecology, endocrinology, fishery biology, genetics, histology, ichthyology, invertebrate zoology, morphology, physiology, or population dynamics.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

The bachelor's program must show emphasis on zoological subjects and include adequate preparation in mathematics and physical sciences. Each applicant must provide Graduate Record Examination scores, letters from two persons most familiar with his academic qualifications, and a personal statement of his primary interests and objectives.

Admission is restricted to students who have a baccalaureate degree in a biological science and who present a cumulative undergraduate average of at least 3.00. Each applicant must provide scores from the Graduate Record Examination, letters from two persons who are familiar with his academic competence, and a personal statement of his interests and objectives.

NOTE: *For courses in Zoology and related subjects see Biology, Genetics, and Physiology.*

OTHER ELECTIVE GRADUATE COURSES

The following courses are in fields in which neither major nor minor work is offered at this institution. The courses, however, carry graduate credit and, with the approval of the major department head or program chairman, may be applied toward the requirements for a degree either as elective courses or as a part of a general studies program. The usual restrictions upon the use of 400-series courses in degree programs apply to these courses.

AGRICULTURE, GENERAL (AG)

400. INTRODUCTORY BIOMETRY (3)
430. INTERNSHIP (1-10)

AMERICAN STUDIES (AM ST)

402. SEMINAR IN AMERICAN STUDIES (3-9)

501. THEORY AND METHODS OF AMERICAN STUDIES (3) Theory and methods for the analysis of American culture: history of ideas, analysis of myth and symbol, comparative arts, etc.

502. PROBLEMS IN AMERICAN STUDIES (3-6) A variable-content course, addressed each term to a specific problem, topic, or period in American culture.

ANIMAL SCIENCE (AN SC)

422. QUANTITATIVE INHERITANCE AND ANIMAL BREEDING (3)
455. ANIMAL GENETICS (2)

APPLIED MATHEMATICS (A M)

405. (Math. 405) Fourier Series and Partial Differential Equations (3)
417. (Math. 417) Tensor Analysis (3)
418. (Math. 418, Stat. 418) Discrete Probability Theory (3)
419. (Phys. 419) Theoretical Mechanics (3)
431. (Math. 431) Ordinary Differential Equations (3)
441. (Math. 441) Matrix Algebra (3)
451. Functions of Several Variables (3)
452. (Math. 452) Functions of a Complex Variable (3)
461. (Phys. 461) Theoretical Mechanics (3)
490. Special Topics (1-12)

510-511. Linear Methods (3 each) Matrices, quadratic forms, ordinary and partial differential equations, integral equations, transforms, Fourier series. Prerequisite or concurrent: A.M. 452.

512-513. (Stat. 512-513) Introduction to Stochastic Processes (3) Markov chains, random walk and recurrent events, queuing theory, time-dependent stochastic processes.

520. Asymptotic Techniques in Differential Equations (3) Asymptotic series; applications to ordinary and singular perturbation problems. Prerequisite: A.M. 511.

550. (Phys. 550) Applied Group Theory (3) Representations of discrete and continuous groups, applications to theoretical physics and differential equations, varying emphasis on the specific applications. Prerequisite: A.M. 510 or Phys. 525.

573. Special Topics (2-12) Various topics according to instructor and students. Prerequisite: second-year graduate standing.

THE ARTS (ARTS)

400. Contemporary Forms in the Arts (3)
410. Independent Study in Relating the Arts (3-9)

BEHAVIORAL SCIENCE (BEHSC)

501. Behavioral Science (4) Integration of bio-psycho-social substrates of behavior, variability in behavior during development, and behavioral correlates with disease and health.

502. Behavioral Science (3) Continued integration of bio-psycho-social substrates with emphasis on adaptation, during development, and behavioral correlates with disease and health.

503. Behavioral Science (3) Continued integration of behavioral substrates with emphasis on personality, emotions, nervous system, stress, behavioral correlates of disease, communication, and society. Prerequisite: Beh.Sc. 502.

511. Medical Statistics and Research Design (2) Use of theoretical and applied statistics in medical research design and in the interpretation of data.

521. Primate Behavior (3) Monkey-to-man survey of intelligence, learning, social behavior, emotions, growth, and physiology; techniques of primate research.

531. Behavioral and Physiological Correlates of Stress (3) Effects of stress on all physiological processes and role of learning, cognition, personality, and culture in adapting to stress.

533. Biofeedback and the Control of Internal Responses (2) Discusses theoretical and clinical applications of voluntary control over EEG, cardiovascular and muscle activity, body temperature, and other physiological processes.

535. Nervous Systems and Behavior (3) Synthesis on behavioral science, neurobiology, and physiology with emphasis on integrative functions of peripheral, central, and autonomic nervous systems.

537. Mechanisms of Memory (2) Discussion of physiological mechanisms involved in information storage and retrieval. Experimental design in memory research is emphasized.

540. Seminar (1-6) Critical discussion of current literature and research within the behavioral sciences, emphasizing research design, methods, interpretation, and synthesis.

551. Health, Illness, and Culture (3) A medical sociology seminar devoted to the sociocultural aspects of health and sickness.

555. Behavior Change (3) Review of behavioral science research and theory relevant for behavior change procedures used in medicine.

570. Special Topics (1-6) Original and current literature and research methods in special areas in the behavioral sciences.

590. Research Problems (3-12) Independent work to develop and test creative and original hypotheses.

BIOLOGICAL HEALTH (B H)

403. Child Health Needs and Services (3)

BUSINESS EDUCATION (BUSED)

456. Principles and Problems in Business Education (1-3)
459. Improvement of Instruction in Business Skill Subjects (1-3)
460. Curriculums in Business Education (3)
461. Improvement of Instruction in Basic Business Subjects (3)
462. Teaching of Shorthand and Typewriting (3)
463. Teaching of Bookkeeping (3)

575. Administration and Supervision in Business Education (3) Work of administrators, supervisors, and others responsible for improvement of instruction in business education; use of vocational testing; job analysis. Prerequisite: 6 credits in secondary education.

576. Introduction to Research in Business Education (3) Methods of research in business education; opportunity to compile annotated bibliographies on current problems; analysis and evaluation of significant research.

577. Evaluation of Research and Empirical Literature in Business Education (3) Application of evaluation methods to current literature in business education; special attention to research studies. Prerequisite: Bus.Ed. 576.

578. Seminar in Business Education (1-6) Intended for graduate students preparing theses or final documents, or for those working on special studies in business education. Prerequisite: Bus.Ed. 577.

CHINESE (CHNS)

489. Readings in Chinese (1-6)

COMMUNITY DEVELOPMENT (COM D)

401. Socioeconomic Change and the Process of Dislocation (3)
402. Politics, Policy, and Community Action (3)
403. Ideal Communities (3)
404. Interpersonal and Group Processes in Community Change (3)
405. Community Mental Health: An Ecological Approach to Human Services (3)
406. Planning and Evaluating Human Service Programs (3)
407. Community Conflict (4)
417. Identifying Community Power Structures (3)
418. Community Organizing (5)
419. Comparative Community Development (3)

CONSUMER STUDIES (C S)

416. (I.F.S. 416) Consumer Role of Family (3)
420. Consumer Industries (4)
430. Societal Aspects of Consumer Problems (2)

CULTURAL FOUNDATIONS OF EDUCATION (CF ED)

415. (Anthy. 415) Anthropology of Education (3)
416. (Soc. 416) Sociology of Education (3)
417. Philosophic Basis of Education (3)
418. History of Education in the United States (2-3)
419. History of Education in Ancient and Medieval Times (3)
420. History of Modern European Education (3)
422. Introduction to Comparative Education (3)
466. Race, Poverty and the Schools (3)

515. Experimentalist Philosophies of Education (2-3) John Dewey's educational philosophy and later formulations by Bode, Kilpatrick, Childs, Brameld, and others. Prerequisite: C.F.Ed. 417 or 6 credits in philosophy.

516. Topical Seminar on School and Society (2-6) An intensive and comprehensive analysis of one selected aspect of the relationship of educational institutions to their societal setting. Prerequisite: C.F.Ed. 416.

517. Existential Philosophy of Education (3) The nature, aim, organization, policy, and process of education examined from the viewpoint of existential philosophy and existential phenomenology. Prerequisite: C.F.Ed. 417 or 6 credits in philosophy at the 400 level or above.

519. Contemporary Philosophies of Education (2-3) Implications for education of various types of realism, idealism, existentialism, and analytic philosophy. Prerequisite: C.F.Ed. 417 or 6 credits in philosophy.

521. Education in the Latin-American Countries (2-3) Recent educational progress in Central and South America, with special reference to Mexico, Cuba, Puerto Rico, Brazil, Chile, and Argentina. Prerequisite: C.F.Ed. 422 or 6 credits in Latin-American studies.

522. Comparative European Education (2-3) Educational policies and practices in school systems in western and central European nations. Prerequisite: C.F.Ed. 422.

524. Education in Communist Countries (2-3) Educational policies and practices in Soviet Russia and other Communist countries. Prerequisite: C.F.Ed. 422 or 6 credits in Russian or Asian studies.

526. Education in Developing Countries (2-3) Educational problems and trends in selected countries, with particular reference to Africa, the Middle East, and Southeast Asia. Prerequisite: C.F.Ed. 422 or 6 credits in Asian, African, or Latin-American studies.

528. Education in Canada (2-3) Development and organization of education in the Canadian provinces; emphasis on dual systems of Ontario and Quebec. Prerequisite: C.F.Ed. 422.

532. Social Change, Cultural Dynamics, and Education (2-3) The social role of the school in a rapidly changing society. Prerequisite: C.F.Ed. 416.

534. Readings in Philosophy of Education (1-6) Selected philosophic writings — classic, modern, or contemporary — on education. Prerequisite: C.F.Ed. 417 or 6 credits in philosophy.

536. Educational Leaders and Classics (2-3) Selected leaders and their writings, with emphasis on historical-social context, including Quintilian, Erasmus, Comenius, Fénelon, Pestalozzi, and Mann.

592. Seminar in Cultural Foundations of Education (1-9) Conferences and discussions designed to meet the need for special study of particular areas in cultural foundations of education. Prerequisites: 12 credits of graduate work in cultural foundations of education.

EARTH AND MINERAL SCIENCES (EM SC)

420. (S.T.S. 420) Energy and Modern Society (3)
421. (S.T.S. 421) Materials and Modern Society (3)
496. Special Projects (1-6)

596. Individual Studies (1-6)

EDUCATION (ED)

470. Special Topics in Education for Collaborative Study (1-9)

ENGINEERING (ENGR)

410. (S.T.S. 410) Technology — Its Character, Role and Function (3)
450. Patent Fundamentals (3)

500. Special Topics in Engineering (1-3)

ENGINEERING GRAPHICS (E G)

421. Engineering Graphics for Teachers (3)

ENGINEERING SCIENCE (E SC)

405. Engineering Applications of Field Theory (3)

ENVIRONMENTAL RESOURCE MANAGEMENT (E R M)

400. Senior Seminar (1)
401. Special Studies (1-8)
410. Pollution of Environmental Systems (3)
411. Legal Aspects of Resource Management (2)
412. Resource Systems Analysis (3)
413. Case Studies in Ecosystem Management (3)

FAMILY AND COMMUNITY MEDICINE (FCMED)

510. Normal Sexual Development (1) The basis, development, and pattern of normal sexual development, with an emphasis on the range of "normal."

515. Economics of Health Care (1) Health costs and various means of meeting them.

527. Community Health Agencies (2) Students individually study community health agencies in depth, sharing experiences in seminars with other participants, agency personnel, and faculty.

GEOLOGICAL SCIENCES (G SC)

412. Geology of the Solar System (3)
416. Stable and Radioactive Isotopes in Geosciences: Introduction (3)
471. Field Studies in North America (3)

547. Evolution in Ecosystems (3) Evolutionary attributes of ecosystems; manifestation of evolutionary mechanisms in ecological systems; evolution of interspecies integrations; evolution of selected ecosystems.

Note: *More specialized courses in this field are listed under Geochemistry, Geology, Geophysics, or Mineralogy and Petrology.*

HEALTH PLANNING AND ADMINISTRATION (H P A)

410. Principles of Public Health Administration (3)
420. Environmental Health (3-6)
430. Principles of Health Planning (3)
431. Health Planning Methods (3)
432. Health Systems Management (3)
433. Health Systems Theory (3)
440. Epidemiologic Basis for Planning (3)

HUMAN DEVELOPMENT (H DEV)

400. Special Problems in Human Development (1-6)
401. Professional Issues in Human Development (1-3)
499. Senior Thesis (1-10)

516. Methods of Research in Human Development (1-6) Review of problems and techniques of research in human development.

HUMANITIES (HUMAN)

421. The Politics of Professionalism (3)
431. Science and American Democracy (2)
471. Humanistic Studies (1-4)
490. (C.&S. 490) Humanities for Teachers (3)

504. Human Values in Medical Care (2) Analysis of questions, concepts, and ramifications of moral and religious values of health and illness; principles of professional responsibility.

521. Philosophical Ethics (2) A critical delineation and examination of the conceptual framework of ethics.

526. Philosophy of Science (2) An introduction to the basic concepts of the philosophy of science.

570. Special Topics (1-6) Specialized study of selected topics in the humanities.

INTERDISCIPLINARY PROGRAM IN THE HUMANITIES

Qualified students who wish to receive a Ph.D. degree in one of the graduate major programs in the College of the Liberal Arts or the College of Arts and Architecture, and yet would like to receive an interdisciplinary education, may enter the interdisciplinary program in the humanities after they have been properly enrolled in one of the major programs, provided their interdisciplinary interest lies within the realm of the humanities.

INTERNATIONAL UNDERSTANDING (INT U)

400. World Affairs and International Understanding (3-6)

ITALIAN (IT)

415. Dante (3)
420. Petrarca and Boccaccio (3)
425. The Literature of the Italian Renaissance (3)
450. Nineteenth-Century Italian Literature (3)
460. Twentieth-Century Italian Literature (3)
497. Problems in Italian Literature (3-10)

588. Seminar in Italian Literature (3-12) Common and individual research in special problems.

LABOR STUDIES (L S)

400. Comparative Industrial Relations Systems (3)
411. Trade Union Administration (3)
413. (Econ. 413) Comparative Labor Movements (3)
414. (Econ. 414) Theories of the Labor Movement (3)
415. Labor Movements in Developing Areas (3)
433. (Pl.Sc. 433) The Law of Labor-Management Relations (3)
435. Labor Relations in the Public Sector (3)
454. (Soc. 454) Industry and the Community (3)
455. (Soc. 455) The Sociology of Work (3)
456. (Hist. 456) History of American Organized Labor Since 1877 (3)
457. (Soc. 457) Field Work in Work Organizations (1-6)
489. Problems in Labor Studies (1-9)

LANDSCAPE ARCHITECTURE (LARCH)

400. Special Studies (1-6)
431. Landscape Design — Area Analysis (3)
432. Landscape Design — Site Analysis (3)
433. Landscape Design — Detail Analysis (3)
434. Urban Park and Recreation Areas (3)
437. Basic Landscape Construction (3)
439. Advanced Landscape Construction (3)
441. Landscape Design — Detail Design (3)
442. Landscape Design — Area Design (3)
443. Landscape Design — Site Design (3)
444. Landscape Architecture Field Trip (1)
451. Comprehensive Landscape Design I (4)
452. Comprehensive Landscape Design II (4)
453. Comprehensive Landscape Design III (4)
457. Professional Practice (2)
458. Advanced Landscape Communications (2)
471. Park Systems (2)
472. Planning and Public Policy (3)
473. Recreation Resource Planning (3)
474. Site Engineering Fundamentals (1)
475. Park Systems Practicum (1)
491. Landscape Seminar I (1)
492. Landscape Seminar II (1)
493. Landscape Seminar III (1)
497. Selected Studies (3)

518. Advanced Problems in Landscape Design (2-12) Selected problems for original investigation in the design, construction, and maintenance of landscape architectural projects.

521. Technical Landscape Architectural Practices (2-12) Specific technical and professional problems in landscape architectural planning and practice. Prerequisites: L.Arch. 462, 471.

LAW ENFORCEMENT AND CORRECTIONS (L E C)

401. Probation, Parole, and Pardons (3)
410. Correctional Counseling Processes (3)
430. Correctional Institutions and Services (3)
470. Law of Crimes and Corrections (3)
480. Research Literature on Crime and Corrections (3)

LIBERAL ARTS (L A)

450. Independent Study (1-9)
460. Undergraduate Internship (1-6)
461. Academic Adviser Training (1)
480. (S.T.S. 480) Technological Change and Human Values (3)
482. Quantitative Methods for Humanists I (3)
483. Quantitative Methods for Humanists II (3)
489. Undergraduate Seminar: Selected Topics (3-9)

LITHUANIAN (LITH)

500. Structure of Lithuanian (3) Analysis of the phonology, morphology, and syntax of Lithuanian; comparative linguistic study of Balto-Slavic and Indo-European. Prerequisite: one graduate course in linguistics.

MATERIALS SCIENCE (MATSC)

401. Materials Science for Teachers I (3)
402. Materials Science for Teachers II (3)
404. Process Measurement and Control (1)
406. Introduction to Biomedical Materials (3)
411. (Min. 411) Instrumental Techniques Applied to Materials and Mineral Science Problems (1-6)
Unit A. X-Ray Diffraction
Unit B. Transmission Electron Microscopy
Unit C. Spectroscopy
Unit D. Electron Microprobe Analysis
Unit E. Scanning Electron Microscopy
Unit F. Absorption Spectroscopy
412. Quantitative Microstructural and Particulate Characterization (1)
416. Materials Preparation (2)
420. Mathematical Modeling for Materials Scientists (3)
421. (Min. 421) X-Ray Diffraction (3)
490. Special Topics in Materials Science (1-9)

500. Materials Research for Teachers (3) Independent research on a problem from materials science. Topic chosen by consultation with the supervising faculty. Written report required. Prerequisite: Mat.Sc. 402.

512. (Gchem. 512) Principles of Crystal Chemistry (2-4) Relation of structure to ionic size and nature; influence of pressure and temperature on structure; chemical-structural defects, crystalline solutions, phase-transitions.

514. Characterization of Materials (3) Classical and new (microprobe, scanning microscope, magnetic resonance, and Mossbauer) techniques for the characterization of composition, structure, defects, and surfaces.

524. (Gchem. 524) Vibrational Spectra of Materials and Minerals (2) Infrared and Raman spectroscopy of solid materials with applications to crystal chemistry, materials characterization and glass research. Prerequisites: Phys. 412, 471.

531. (Min. 531) Transmission Electron Microscopy (2) Discussion of electron image contrast theory as a tool for study of atomic substructures in the materials and mineral sciences. Prerequisite: Mat.Sc. (Min.) 411B.

532. (Min. 532) Structure Analysis (2) Crystal structure determination methods; space groups, structure factors, heavy atoms an isomorphous replacement, Fourier synthesis, Patterson maps, inequalities, refinement techniques. Prerequisite: Mat.Sc. (Min.) 421.

533. (Min. 533) Single Crystal Methods (2) Experimental techniques in crystal structure determination: crystal selection, space group determination, measurement of intensities, analysis of data. Prerequisite: Mat.Sc. (Min.) 421.

534. (Min. 534) Diffraction by Crystals (2) Interaction of radiation with matter: coherent and incoherent scattering, extinction, fluorescence, polarization. Prerequisite: Mat.Sc. (Min.) 421.

535. (Min. 535) Geometrical Crystallography (3) Derivation of lattices, types, point groups and space groups with applications.

538. (Min. 538) Electron Beam Analysis of Solids via X-Ray and Electron Emission (3) Theory of phenomena occurring in electron-bombarded solids and their applications to analysis of solids.

540. Crystal Anisotropy (2) Symmetry aspects of crystals and physical properties. Matrix and tensor methods. Prerequisite: Phys. 412.

542. Magnetic Methods in Materials Science (3) Static magnetic (susceptibility type) and spectroscopic methods (nuclear and electron magnetic resonance, Mossbauer spectroscopy) for materials characterization and structural analysis. Prerequisite: Phys. 413.

550. Evaporation and Condensation of Solids (2) Thermodynamics of evaporation and condensation of solids; condensation processes including thin films and epitaxial growth and their applications.

552. Theory and Practice of Crystal Growth (3) Theoretical approaches to crystal growth and of the various techniques used in growing crystals.

554. Electronic Spectra of Materials (2) Crystallographic and thermodynamic applications of crystal field theory. Electronic spectra of crystals and glasses. Luminescent spectra and phosphor characterization. Prerequisite: Phys. 471.

564. Structure and Properties of Carbons and Graphite (3) Relation of the ideal and defect structure of polycrystalline carbons and graphite to their mechanical, electronic, thermal, and optical properties. Prerequisite: Phys. 412.

570. Catalytic Materials (3) Preparation and characterization of solid catalytic materials. Relationships between their surface, defect, and electronic properties and catalytic activity. Prerequisite: Chem. 452.

597. Special Topics (1-6)

MINERAL ENGINEERING (MIN E)

424. (Metal. 424) Coal Preparation (3)

PATHOLOGY (PATH)

501. Principles of Pathology (4) The fundamentals of reaction to injury at cellular and tissue levels emphasizing the pathogenesis of functional, structural, and biochemical abnormalities. Prerequisite: admission to College of Medicine.

502. Principles of Pathology (4) The fundamentals of human disease with emphasis on pathogenesis of functional, structural, and biochemical abnormalities at the organ system level. Prerequisite: admission to College of Medicine.

510. The Clinical Laboratory in Laboratory Medicine (5) Seminars, tutorials, and independent analysis by the student of specific laboratory problems which relate to human disease. Prerequisites: admission to College of Medicine; Path. 501, 502.

513. Applied Surgical Pathology (4) Students will study tissues daily received by the surgical pathology laboratory. Problems encountered in many clinical specialities will be considered. Prerequisites: admission to College of Medicine; Path. 501, 502.

516. AUTOPSY PATHOLOGY (5) Students will first assist in and then perform autopsies under supervision. Emphasis will be on correlations with clinical and experimental medicine. Prerequisites: admission to College of Medicine; Path. 501, 502.

520. BIOLOGY OF NEOPLASIA (3) Detailed examination of the initiation and pathogenesis of animal neoplasms with emphasis on the relationship to human neoplasia. Prerequisite: admission to College of Medicine.

524. BIOLOGICAL MEMBRANES, STRUCTURE AND FUNCTION (2) Critical consideration of biological membranes emphasizing comparative structure and biochemical composition through small group discussion and review of current literature. Prerequisite: admission to College of Medicine.

530. TROPICAL PATHOLOGY (4) Study of diseases commonly encountered in tropical areas with emphasis on parasites and infectious and nutritional disorders. Prerequisites: admission to College of Medicine; Path. 501, 502.

540. DEVELOPMENT OF EDUCATIONAL TOOLS AND METHODS IN PATHOLOGY (3) Development of new educational tools and methods to teach pathogenesis of disease to patients, medical students, and medical technology students. Prerequisite: admission to College of Medicine.

560. PATHOLOGY SEMINAR (1) Staff and student seminar covers current research, educational and service developments in the field. Prerequisite: admission to College of Medicine.

570. SPECIAL TOPICS IN PATHOLOGY (1-6) Specialized training in advanced research techniques available in the department. Prerequisite: admission to College of Medicine.

590. RESEARCH PROBLEMS IN PATHOLOGY (1-12) Individualized research on pathology problems conducted by students in medical school laboratories. Prerequisite: admission to College of Medicine.

PHYSIOLOGY (PHSIO)

520. MEDICAL PHYSIOLOGY (2) Cellular physiology including membrane permeability, bioelectric potentials, muscle contractions, secretion; metabolic physiology, including control of metabolism by hormones.

521. MEDICAL PHYSIOLOGY (3) Organ physiology; examination of respiratory, renal, gastrointestinal and cardiovascular physiology.

522. PHYSIOLOGY LABORATORY (1) Practical exercises in the areas of neuromuscular physiology, metabolism and endocrinology. Prerequisites: one year of biology, two years of chemistry, and one year of physics. Concurrent: Phsio. 520.

523. PHYSIOLOGY LABORATORY (1) Practical exercises in the areas of cardiovascular, respiratory, renal and gastrointestinal physiology. Prerequisite: Phsio. 520. Concurrent: Phsio.521.

525. GENERAL PHYSIOLOGY (2) Cellular processes of accumulation membrane transport, bioelectric potentials, contraction, and secretion in erythrocytes, nerves, sensory receptors, muscles, glands, excretory organs.

530. METABOLIC AND ENDOCRINE PHYSIOLOGY (3) Regulations of carbohydrates, fatty acid and protein metabolism; regulation of hormone secretion; effects of hormones on water and cell metabolism.

532. REPRODUCTIVE PHYSIOLOGY (3) Physiology of male and female reproductive systems, including synthesis, regulation of secretion, and mechanism of action of the steroids and polypeptide hormones involved. Prerequisites: Phsio. 520, 521.

534. HEART AND SKELETAL MUSCLE (2) Discussion of structure, chemistry, and physiology of heart and skeletal muscle. Prerequisites: Phsio. 520, 521.

536. GASTROINTESTINAL PHYSIOLOGY (2) Mechanisms of absorption and secretion by stomach, intestine, pancreas, and gallbladder. Neural and hormonal regulation, bioelectric potentials, pathophysiology. Prerequisite: Phsio. 521.

550. SEMINAR (1 per term) Critical appraisal by staff and students of current research developments and of data collected in current investigations.

570. SPECIAL TOPICS (1-6) Training in the use of research techniques; examination in depth of a specialized topic on the level of current research.

590. RESEARCH PROBLEMS (1-12) Individualized research conducted by students in departmental laboratories.

PLANT SCIENCE (PLTSC)

400. PRINCIPLES OF PLANT SCIENCE RESEARCH (2)
401. INDEPENDENT STUDY IN PLANT SCIENCES (1-6)

POLISH (POL)

501. READINGS IN POLISH LITERATURE (3-6) Individual reading and research in nineteenth- and twentieth-century Polish literature and literary criticism.

POLYMER SCIENCE (PLMSC)

406. INTRODUCTION TO THE MATERIALS SCIENCE OF POLYMERS (3)
407. TECHNOLOGY AND APPLICATIONS OF POLYMERIC MATERIALS (3)
408. POLYMERIC MATERIALS LABORATORY (1)
409. INTRODUCTION TO PROPERTIES OF POLYMERIC MATERIALS (3)
410. POLYMER-BASED COMPOSITE MATERIALS (3)

560. PROPERTIES OF POLYMERIC MATERIALS (3) Macroscopic and microscopic behavior of polymeric materials. Interpretation of properties in terms of structure. Prerequisite: Plm.Sc. 406.

562. POLYMERIC MATERIALS CHARACTERIZATION LABORATORY (2) Characterization of polymeric materials by chemical and physical methods. Prerequisite: Plm.Sc. 406.

565. POLYMERIC BIOMEDICAL MATERIALS (3) Synthetic high polymers: their properties and uses in biomedical applications.

POPULATION ISSUES

Qualified students may select Population Issues as an optional area of specialization when majoring in either economics, geography, or sociology. Additional information is given under the description of those majors in the preceding section.

PORTUGUESE (PORT)

588. SEMINAR IN PORTUGUESE AND BRAZILIAN LITERATURE (3-12) Common and individual research in special problems.

SAFETY EDUCATION (SAFED)

449. SAFETY EDUCATION (3)
450. VISUAL AND OTHER AIDS IN SAFETY EDUCATION (3)
451. TEACHING TRAFFIC SAFETY AND AUTOMOBILE OPERATION (3)
452. ORGANIZATION AND SUPERVISION IN SAFETY EDUCATION (3)

SCIENCE (SC)

400. CONSEQUENCES OF SCIENCE (1)

SCIENCE, TECHNOLOGY, AND SOCIETY (S T S)

410. (Engr. 410) TECHNOLOGY: ITS CHARACTER, ROLE, AND FUNCTION (3)
420. (E.M.Sc. 420) ENERGY AND MODERN SOCIETY (3)

421. (E.M.Sc. 421) Materials and Modern Society (3)
430. Food and Man: Technology and Feeding the World Population (3)
435. (Phil. 435) The Interrelation of Science, Philosophy, and Religion (3)
450. Technological Change: Its Production, Diffusion, and Impact (3)
460. Science and Public Policy (3)
470. Technology Assessment and Indicators of the Quality of Life (3)
471. Radiation, Reactors, and Society (3)
480. (L.A. 480) Technological Change and Human Values (3)

Note: This program is designed to examine critically the impact of scientific investigation and technological development on society and the influence of human needs on scientific investigation and technological development.

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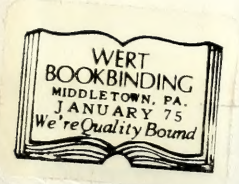
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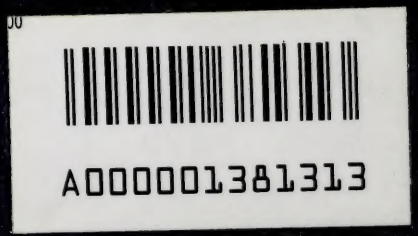
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